3-7-2020

Making a smoother transition for children with Diabetes mellitus type 1 using a serious game

Graduation Project – Creative Technology

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Abstract

This paper describes the process of the generation of a list of requirements that is needed to design a useful and educational game for children with Diabetes Mellitus type 1 (DMT1) and their parents. The goal of the game is to give the children that have had recent diagnoses or must take more responsibility for their disease more structure in their life. And with this, teaching them more about their Diabetes. To generate this list of requirements designs and prototypes were made to support this list.

The first prototype is based on a literature review, background information and interviews with Diabetes specialist. The first list of requirements was then used to generate a second prototype for the parents and the children's version. These prototypes were evaluated using the UTAUT model. This evaluation was then used for a third iteration for the parents. In the end two final prototypes were made, one for the children and one for the parents. Using all the information from previous chapters, the prototypes and the results of the evaluation, the final list of requirements was made. In further research, there could be investigated more specific DMT1 tasks and more specific data visualization.

Acknowledgments

After a long and interesting academic life here in Enschede it must come to an end. I want to take a moment to look back at all the people that have helped and supported me in this time.

First, I want to thank my supervisor Laura Schrijver for the endless support in my project. She helped me stay motivated and guided me through a long and sometimes difficult process. I also want to thank Miriam Vollenbroek-Hutten for making it possible for me to start and finish my own project.

Also, a big thank you to Diabeter and de Hoeksteen for helping me find participants for the evaluations. I also want to thank all the participants for participating in my evaluations and giving me the feedback to make an end product that I am very proud of.

Last, I want to thank all my friends and family for the support they have given me, not only this year but also the years before that. Especially my mother Irmgard Hemmerlé, that has always been there for me and helped me in a lot of different ways during the project and before that.

Thank you all,

Jaimy de Kok

Enschede, July 1st, 2020

Table of Contents

Table of tables

Table of figures

1 Introduction

During this chapter, Diabetes Mellitus type 1 will be explained, and a short description will be given about what serious games entail. After this, the objective of this essay and the limitations and challenges will be addressed. Following from this, the goal and a research question will be formulated with sub-questions to help answer the research question.

1.1. Background

DMT1 (Diabetes mellitus type 1) is an autoimmune disease. This means that the body attacks the cells in the pancreas that make the insulin. Normally, carbohydrates get turned into glucose which then get distributed to different organs in the body. Insulin makes sure that the glucose goes from the blood into the organs and other parts of the body to make sure that the body has enough energy to function. When a person has DMT1 this does not happen on its own. Another way to get the insulin into the body is needed. This can be done via needle injections 3-4 times a day. Or an insulin pump which is attached to the body via a small tube that the patient uses 24/7. A cure is not yet found which means that most people need to live with DMT1 for their whole life.

In the Netherlands around 100.000 people have diabetes type 1, approximately 6000 of those are between the ages of 0 and 18 (Diabeter, 2019b). 6000 sounds like a lot, because it is a lot. DMT1 is a disease that usually is diagnosed when a person is around the age of 14 (J. N. MD, 2019). The disease can be diagnosed as early as after birth. This period in people's lives is a vulnerable time. Children are still growing up and learning things about the world and themselves. When they get diagnosed with this kind of life changing disease, it is hard to comprehend what that will mean for their life. The disease does not only have an effect on the children, but also on the rest of the family (Golics, Khurshid, Basra, Salek, & Finlay, 2013). When not treating DMT1 well it can lead to cardiovascular disease, bad eyesight, kidney disease, high blood pressure etc. (WebMD) This is why most of the time the parents will take care of everything surrounding the child when it comes to their DMT1. At some point in their life, around the age of 8, the child needs to learn how to count carbohydrates, give themselves insulin and be responsible for their own health. It can be hard for the child and parents to make this transition. Since it is about a person's health and future, it is important to make sure that they learn how to deal with their disease well.

To teach children how to take care of their disease, technology can be used. One of these types of technology is a serious game. Serious games are used in many different fields, as stated by (Laamarti, Eid, & El Saddik, 2014) such as: Military, education, job training etc. Since technology has grown a lot in the last few decades, serious games have become a central part of helping people get more familiar with certain subjects, software, or situations. It is used more and more and since children are growing up with technology these days, using this as a focus point to help children with their diabetes could be beneficial. Before we can go deeper in this subject a clear definition of serious games is needed. Giving a definition to the concept "serious games" can be quite difficult. Different players in this field say different things. But most agree on the following core explanation, ***"Serious games are (digital) games used for purposes other than mere entertainment."*** (Susi, 2007). This definition will be further used during this project. If the definition used in later parts of this essay, would differ from the above definition, the proper source and reason for using an alternative definition will be made clear.

1.2. Challenges

The biggest challenge would be to the make the game interesting enough for the children to keep playing. If they play the game only once, then it will not have any effect. Making sure that they like the game and feel the need to play it repeatedly, would be very challenging.

Next to this, finding what the children find the most difficult about DMT1 and making a simple game form this information could prove difficult.

Also involving the parents in a way that is beneficial and easy for them to use and understand could be a difficult task.

1.3. Goal & Research Questions

As shown in this chapter, DMT1 is a life changing disease and takes a lot of work to get and keep under control. More so for children, they do not understand the impact that this disease has on their lives and on the lives of their parents. Since the younger children cannot take care of everything related to their DMT1, the parents need to step in to keep everything under control. The children are being taught about all the things they need to do daily to stay healthy, but it can be hard for them to retain all this information and use it during the day.

Creating something that can help during this process is the goal of this research. The focus will be on creating a sense of structure in their lives and teach the children certain aspects of DMT1. What these aspects will be, is researched in later chapters. Since making a game interesting for a lot of different age groups is difficult, the focus will be on children between 6 and 12. Another aspect of why this focus group was chosen, is that the child either has a recent diagnoses of DMT1 or that they are in the transition from letting the parents manage the disease to letting the children do this themselves. This is the point in the educational program that could use the most help.

To help achieve the above goals, the following research question and sub-questions were formulated.

This bachelor thesis will try to answer the following research question: ***What are the requirements for a functional and educational serious game for children with DMT1?*** To help with answering this research question, 3 sub-questions have been formulated:

1. What are the problems facing children, parents and the diabetes specialists when trying to control and life with DMT1?
2. How can we involve the parents and/or diabetes specialist in the game in a constructive way?
3. What are the requirements to create a serious game that focusses on improving the life of a child with DMT1?

These questions will be used in the following research. Some form of these questions will be used during the literature review. Both can be found later in this essay.

2 Theoretical framework

Before a serious game can be made, it is important to know what DMT1 entails so it is easier to focus on the aspects that will be used for the serious game. Next to this it is important to look at the current state of serious games used for healthcare and more specifically for DMT1. This is a basis for the literature research that follows.

2.1. Diabetes mellitus type 1

During this section, DMT1 one is explained, and research is done into what types of treatment there are and what some possible complications can be when the disease is not treated in a proper way.

2.1.1 What is it?

In short, DMT1 is an autoimmune disease. This means that the body of a patient with DMT1 attacks the body by mistake. It thinks that the cells in the pancreas that make insulin are foreign cells, which results in the body attacking and destroying some if not all the cells that produce insulin which are called islets of Langerhans. The effect of the body not producing insulin anymore, is that the glucose that normally would be used in various places in the body for energy, stays in the bloodstream of a patient. This can lead to some serious issues and when the blood-sugar level is too high for the body to handle, the patient can fall into a coma. To get a little deeper into what DMT1, this part of the research will talk about glucose, insulin and what happens when the body does not make any insulin anymore.

Glucose comes from foods that are rich in carbohydrates. For example, bread, potatoes, and fruits. The food travels through your esophagus to your stomach. In the stomach, the food is broken down in smaller pieces. One of the things the food is broken down into is glucose. In your intestine it is absorbed and travels further through the bloodstream ("What is glucose?," 2019). Next to amino acids, most of the cells in the body use glucose. When the body has used enough energy, the left-over glucose is stored into little bundles called glycogen in the muscles and liver. The body is designed to keep the glucose level on a stable point. Beta cells in the pancreas monitor this level. And release insulin when needed.

Insulin is a hormone that signals the liver, muscles, and fat cells to take in the glucose that are present in the blood. The glucose can then be used as energy. If the body has received enough energy, it signals the liver to take up the glucose and turn it into glycogen to store it (Editor, 2019). The insulin travels to the correct cells and it “unlocks” the channel so the glucose can enter that cell. Next to helping move the glucose to the right cells, insulin also helps with breaking down proteins for energy.

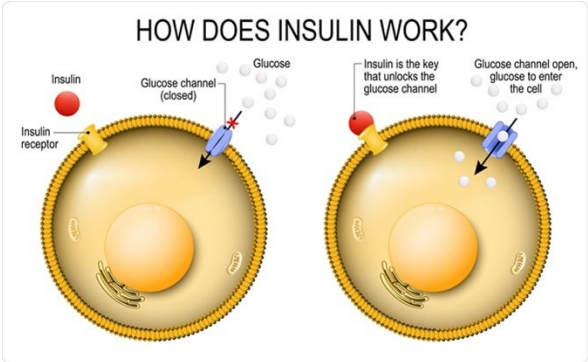


Figure 1 - How does insulin work?

The islet of Langerhans contain beta, alpha and delta cells. The beta cells produce insulin, which are also the cells that get attacked by the body when a person has DMT1 (Amercia Diabetes Association, 2019). When the blood-sugar levels get to low, the alpha cells step in and produce glucagon. This signals the liver to turn the glycogen into glucose. This then travels back to the bloodstream to make sure that the blood-sugar levels don’t drop to low ("What is glucose?," 2019).

There are multiple things that happen to a person's body when the pancreas stops making insulin. Because there is no insulin in the bloodstream anymore, the glucose cannot travel to the cells that need the energy. The body starts to look for other sources of energy since it does not get any glucose in the cells, even though there is still enough glucose in the bloodstream. When this happens, a person has DMT1.

2.1.2 Symptoms, Diagnoses and Treatment

Symptoms

DMT1 is often diagnosed in young children. The disease develops during the younger years, it can be diagnosed at birth, but it can also take a couple of years for the disease to be discovered since the symptoms are often recognized as unrelated to each other.

DMT1 can have multiple different symptoms that stem for the rise in a person's blood-sugar. The following symptoms are often linked to DMT1:

1. Urinating often, this can result in a bladder infection. ("Diabetes and Its Impact on Your Urinary and Sexual Health," 2017)
2. Feeling very thirsty, even though a lot of water or fluids are already consumed.
3. Feeling very hungry, even though enough food has already been consumed.
4. Weight loss, even though the patient is eating more, he/she is still losing weight. This is because the body has the idea that they do not get enough glucose in the cells and start to break down fat to fill in these gaps even though there is already enough glucose in the bloodstream.
5. Extreme fatigue.
6. Blurry vision.
7. Cuts/bruises that heal slow.
8. Irritability or behavior changes
9. Fruity-smelling breath

Most of the time, these symptoms may seem unrelated to each other. That is why it can be difficult to get a fast and good diagnoses. It is important for parents to be aware of the possible symptoms, the earlier the diagnoses the better. (clinic, 2020)

Diagnoses

After recognizing the symptoms, a parent can take the child to get a blood test. These are easy to do; the doctor uses a small needle to prick unto the child's finger and inserts the blood onto a strip that is in a blood glucose monitor. A normal patient has a blood-sugar level between 4 and 8. When the child measures higher than this, most of the time higher than 11, there is a possibility of DMT1 being the cause. Next to this fast way of checking the blood-sugar, there is also a test that can measure the average blood-sugar levels from the last 2 to 3 months, to a value called HbA1c. It measures the blood-sugar attached to the hemoglobin. If the HbA1c level is higher than 6.5% on two different test, then that means that the patient has DMT1 (clinic, 2019).

Treatment

Since DMT1 is a chronical disease, it cannot be cured. The patient needs to treatment for the rest of their lives. There are several different things that need attention during the treatment, especially in the early stages. Including checking blood-sugar levels with either a sensor or using a small amount of blood. Insulin injection is another part of the treatment, either needles are used or a small pump.

One of the first things that happen when DMT1 is diagnosed, is teaching the patient and most of the time the parents what living with the disease entails. This part is crucial, since it is important to teach the patient everything, they need to know so they can have an easy and healthy live. During these sessions, the doctor explains what DMT1 is, where it comes from and what they need to do to control the disease.

Glucose monitor

Checking the patient's blood-sugar regularly is one of the most important parts of having control over the disease. There are two options for checking some one's blood-sugar level.

The first is using a finger prick and inserting this blood into a small device. This is the most standard and used way to check the blood-sugar levels. The device shows what the level is in that moment, so it can be hard to see what has happened before that moment or where the level is going. There are a lot of different devices made by different companies. Some of these, like the one in figure 2, is one that can connect to an insulin pump. If the patients has a pump, this connection makes it easier to insert the insulin in the body according to the blood-sugar level.

Figure 2 - Contour next link

There is also the option of a Continuous glucose monitor (CGM) or a Flash glucose monitor. These devices constantly measure the blood-sugar level in a patient's body. The CGM consist of a sensor, a sender and a receiver. The sensor is placed on the stomach of a patient most of the time. It measures a patient Blood-sugar level in the subcutaneous tissue fluid (Burckhardt, M. A., et al (2019).). In figure 3 you can see the way that these devices work. The sensor measures the glucose level and the transmitter sends it to the receiver. The receiver is mostly a pump, if these two devices are not compatible, a phone can also be used.

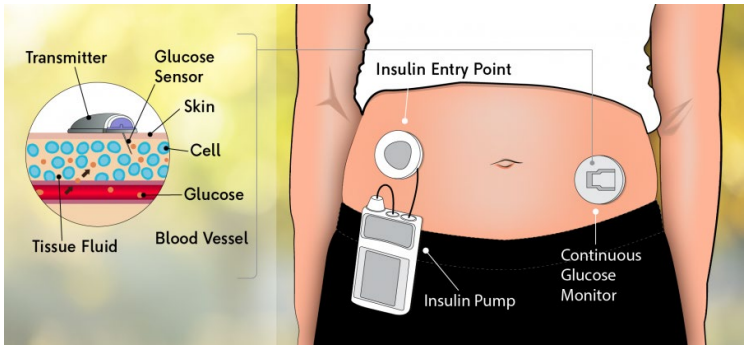


Figure 3 - CGM

Another option is the Flash glucose monitor (FGM). This system consists of a sensor and a receiver but no transmitter. These devices, such as the very popular free style libre, use a phone or another scanning device that needs to be placed close to the sensor so it can retrieve the information from the sensor.

The other parts of the system work the same as the CGM. The sensor measures the amount of glycose in the subcutaneous tissue fluid. This device can store up to 8 hours of information without scanning.

Figure 4 - Free style libre (FGM)

Insulin treatment

Next to monitoring the blood-sugar levels very closely, it is also very important that the right amount of insulin is injected into the patient. There are two different ways this can be done for patients with DMT1.

The first one is using a needle. This method is used when a person is just starting with the treatment. Together with the doctors an insulin ratio is set up for the patient. This ratio is for who much insulin a patient needs for a certain amount of carbohydrates. In the beginning a patient can still be producing a small amount of insulin, this is called the honeymoon phase. It is important to monitor the insulin intake and how a patient reacts well so it can be changed accordingly.

Figure 5 - Insulin needle

There are 5 different types of insulin. Rapid-acting, regular, or short-acting, intermediate-acting, long-acting, and ultra-long-acting. Per category there are different types and brands of insulin. The doctor recommends the insulin that fits the patient the best after some tests and questions. Most of the time a combination between fast acting and slow acting insulin is needed. The fast-acting insulin is used before eating a meal. The long-acting insulin is used once a day to keep the blood-sugar levels stable during the day.

Another option for injecting insulin can be the insulin pump. This pump is always attached to the patient. Depending on the type of pump, it has a compartment were the insulin is stored which is sent to the body via a plastic tube that connects to a small bandaged with a tube attached that goes into a patient's fat layer (see figure 6). This system requires some further examination form the doctors since it requires some additional information to keep the insulin and blood-sugar levels stable. When the information is put into the pump, the pump can work on itself for most of the time. There are options where the pump calculates the insulin a patient needs to inject by itself if the right blood-sugar level and amount of carbohydrates a person eats is put into the system. Every 3 or 4 days, the bandage with the small needle needs to be replaced to counter the tissue that forms around the small wound. Using this system gives the patient a lot more freedom to do what he/she wants. Most of the time when I child uses a pump; they are better at regulating the blood glucose levels and have less fluctuations (Diabeter, 2019a). The insulin also gives parents and children more freedom. It is not necessary to inject insulin at a certain time anymore. The biggest change can be seen in school, since the child can easily do it themselves, or the can teacher help.

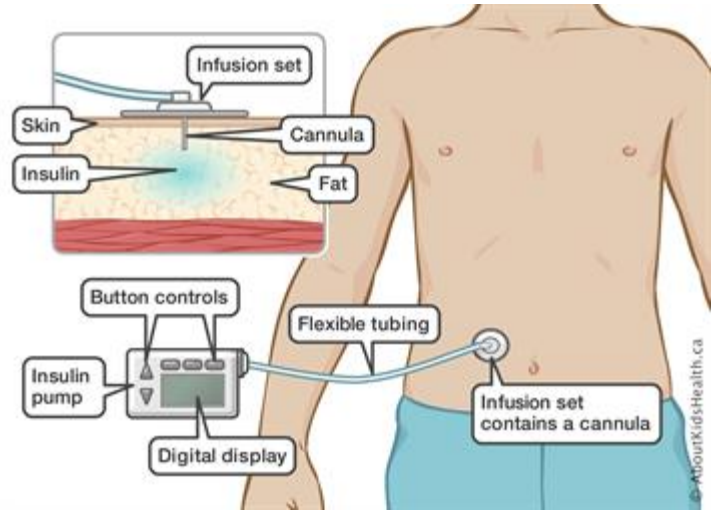


Figure 6 - Insulin pump

2.1.3 Complications

Short term

Low blood-sugar

When a person has a low blood-sugar (hypo glycaemia or hypo), which happens when the blood-sugar level gets below 4, the body does not have enough glucose to use as energy. The patient can become dizzy, nauseous, very hungry, feeling shaky, confusing, sweating chills and clamminess, feeling sleepy, disorientation and anxiety. Most of the symptoms do not happen all at once or not at all. A low blood-sugar level can trigger the release of epinephrine (adrenaline) (American Diabetes Association, 2019). This is what can cause the thumping heart, sweating, tingling and anxiety. Of the blood-sugar level continues to drop, the there is no energy going to the brain anymore which can cause a person to faint and eventually fall into a coma when not treated fast. The best thing to do when experiencing a hypo is to eat some fast sugar to get the blood-sugar level up fast and eat some slow working sugar to keep it stable. The 15-15 rule is that a patient eats 15 grams of sugar and checks after 15 minutes of the blood-sugar level has gone up, otherwise the patient eats another 15 grams of sugar and continues this till the blood-sugar level is above 4 again.

High blood-sugar

When a person's blood-sugar gets to high it is called hyper glycaemia or hyper. People that got the diagnoses of DMT1 often have had hyper glycaemia for a long time, it can still occur when a person is being treated for DMT1. Hyper glycaemia is a result of too much sugar in some one's blood. It can be triggered by stress, an illness, eating too much, lack of exercise, missing an insulin dose or taking other types of medication. This can lead to extreme hunger, thirst, dry mouth, needing to pee frequently, tiredness, blurry vision, feeling or being sick, fruity smelling breath, weight loss, reoccurring infections and tummy pain (NHS, 2019). The best course of action when this happens is to inject some extra insulin. How much this should be is decided together with the doctor when a diagnosis has been made.

Long term

Microvascular complications

There are three complications that fall under microvascular complications; eyes, kidney and nerve disease (Smith-Marsh). All these complications can be prevented by living a healthy life and keeping ones DMT1 under control.

Because of DMT1 the eyes can develop cataracts and/or retinopathy in the eyes. Retinopathy means damage to the retina and is more common than cataracts is for people with DMT1. But both can cause loss of vision. A yearly checkup is mandatory to prevent any complications when they arise. Since it is a common complication. Another complication is diabetic nephropathy, this disease prevents the kidneys from doing their normal job of removing waste products and extra fluids from the body (Staff, 2019). This disease develops slowly and if noticed on time, it can be prevented, or the process can be slowed down. Diabetic neuropathy can damage nerves throughout the body. It is one of the most common complications of DMT1, the best know type of diabetic neuropathy is called diabetic peripheral neuropathy. It can cause burning, stabbing or electric-shock-type pain or tingling in your feet, legs, hands and arms (Toft, 2017). The nerve damage can be caused by the damage that was done to the blood vessels in that area. For DMT1 patients the feet are the most vulnerable and it is advised to get them checked out at least once a year. (D. J. T. MD, 2018)

Macrovascular complications

DMT1 can lead to plaque and eventually build op in the larger blood vessels. This build up can lead to a heart attack later in life. A similar process to the attacking of the body to the isle of Langerhans, can happen overtime to the heart muscles when the blood-sugar is not kept under control (news, 2018). DMT1 patients have higher risk of heart disease, but not all the reasons for this have been understood yet.

2.1.4 Controlling Diabetes mellitus type 1

To get a better understanding of where the problem lies with getting and keeping control over peoples, and more importantly children's DMT1, a literature review was done. This also includes the way the research was done.

Research method

In this case, the search tactic was based on the question: ***What are the problems facing children, parents and the diabetes specialists when trying to control and life with DMT1?*** The question was split up in different aspects that can be used during the search, Diabetes AND Control AND Children. The focus of the literature review was put on children, since this is the focus group of this research, but some results also generated some information that included the parents. Mainly Scopus was used during the search, but also IEEE.

Below the exact words that are used for the search can be found. The words in cursive represent the words that have been used to already get some (serious) game related results)

(Diabetes OR Diabetes type 1 OR Diabetes 1 OR DMT1) AND (Control OR Controlling) AND (Children OR child) *AND (Game OR Serious game OR Serious games)*

The goal of using these keywords is to find articles and research that have evaluated in what ways controlling DMT1 is difficult. And to find some solutions that already have been tested involving children. From this, a conclusion can be made regarding know problems which can be used in later phase as a knowledge base for the interviews or further research. Since DMT1 has been a disease that has been researched for a long time, the year limit was set at 2000 to keep it a little more relevant to this time. Below, in table 1, the findings for the two search engines can be found. In the results on games column, another search parameter was added. Either the word 'game' or 'serious games'.

Search Engine	Results	Results on games
Scopus	16.738	15
IEEE	48	7

Table 1 - Search result per engine

A lot of the results focused on DMT2 which is not something that is needed for this research. Also, some of the articles talked about other research papers so using the references from different papers, more usable papers were found. From these 5 articles have been selected to be compared in this specific literature review.

Literature review

Controlling DMT1 is challenging, especially for children, and controlling it is very important. There are two different ways to improve the glycemic control.

Structure in the child's life is one of the ways to get the disease under control. During a study done by (Hawkes, Willi, & Murphy, 2019) they discovered that putting a structured educational program in the child's life can improve the glycemic control. However, when the patients were taken of this program the noticed that this improvement was not sustained. The study was done with around 300 children where the diagnoses was done before they were 18 and the average age was 10.2. (Brorsson, Leksell, Andersson Franko, & Lindholm Olinder, 2019) further support this by stating that a GSD-Y (Guided Self-Determination-Young) model specifically tailored to the patient and their family may have a positive influence on glycemic control. The GSD-Y model is used as an addition to regular health care that the patients receive, so it will not completely replace normal treatment. It is recommended that when an additional educational program is introduced for a patient, it needs to be done regularly and for a longer period. Taking the patient of the program early can result in a decrease in glycemic control. (Sawtell et al., 2015) further add that even though a structured program can be beneficial for the children and their parents, the staff found that the uptake was poor and the burden for the staff to organize group sessions was high.

A chronic disease like DMT1 does not only have a big effect on the children but also on their families (Golics et al., 2013). Therefore, another way to get help the children get better control over their DMT1 is to educate the parents and the staff of their schools more. Educating the parents seems quite obvious but can be a big help to the children, especially the younger ones that do not know how to do certain tasks yet. (Lange, Swift, Pańkowska, & Danne, 2014) suggest that when writing instructions for the parents it should be done in the appropriate language and style that is easy to understand. "An integrated education concept for parents combines knowledge, practical self-management skills with psychological advice on parental tasks, and emotional support." (Sawtell et al., 2015) further support this by creating a program that is not only focused on the children, but also on educating the parents. (Burckhardt et al., 2019) has done a specific research into seeing how parents handle a remote monitoring system for their children with diabetes type 1. They found that sleep and peace of mind has improved since they do not have to wake up during the night to check their child's blood sugar level. An increased sense of freedom was detected since they felt more comfortable to leave their home during the day. However, the research also states that some parents felt more anxious and overwhelmed by all the data that they received. But some parents had the opposite feeling. They felt more at ease when the system was used.

A combination of more structure in child's life with the help of doctors and a better education for the parents of these patients, could improve the level of control the patient has on their DMT1. Making sure that there is a good balance between the education and the way other systems are used, like the remote monitoring system, is a key component to improve control and stabilizing the glycemic levels. This is the most important when the diagnoses has just been given or when the transition between the parents taking care of the treatment or letting the child do this themselves. The average age for this process is between 6 and 10 years old.

2.2 Serious games

As mentioned above, structure and help in education is needed to improve control and stabilize a patient's glycemic levels. Since technology and games have become such a big part of the current generation, using these mediums is the easiest and will most likely keep the interest of the patients the best. The definition of a serious game is "a game where the primary purpose is something else then entertainment." This type of technology/game fits the setting of this project the best since the focus of the game is education.

To get a little more background information about serious game, a literature review was done. Also, some current games will be evaluated.

2.2.1 Research method

In this case, the search tactic was based on the question: ***What are the requirements to create a serious game that focusses on improving the life of a child with DMT1?*** The part of the question that the literature review focusses on the concept of serious games. Therefore, the question was split up in different aspects that can be used during the search, Serious games AND Children. The focus of the literature review was put on children since this is the focus group of this research. Mainly Scopus was used during the search, but also IEEE.

Below the exact words that are used for the search can be found. The words in cursive represent the words that have been used to get more specific results.

(Games OR Serious games) AND (Children OR child) *AND (Interested OR Motivation OR Motivated OR Participation) AND Types (of serious games)*

The goal of using these keywords is to find articles and research that have evaluated what serious games are and how to help children stay interested in a game. And to find some examples of games that already have been tested involving children and keeping their motivation. From this, the different types of serious games can be evaluated to see which one would fit the concept the best. When this is combined with the knowledge found about how to keep children interested it will create a base to build the research upon further. Below, in table 2, the findings for the two search engines can be found.

Search Engine	Results	Results on Motivation
Scopus	1202	315
IEEE	330	36

Table 2 - Search results per engine

There were a lot of articles. Since the goal of the research was to find requirements for making a serious game, it was not necessary to filter on what the game was made for. This research also included some articles that explained the origin of serious games and what types could be used.

2.2.2. Types of serious games

There are two different types of serious games, active navigation, and passive observation.

Active refers to the fact that a player has the freedom to choose their next step (Ferguson, van den Broek, & van Oostendorp, 2020). (Conniff, Craig, Laing, & Galán-Díaz, 2010) found that players are more motivated and attentive when presented with a game that lets them choose their own path. This further supports the what (Ysselsteijn, 2001) stated, is that greater involvement and immersion occur when the interaction with the environment is increased. Active games can be very useful when the goal of the game is to memorize a special lay-out (Ferguson et al., 2020), since the player has their own choice of what to do and where to go in the game. This gives them a better opportunity to explore and remember their surroundings. However, it can be more difficult for the player of these types of games to retain information since the game gives the player freedom to do and choose what they want. If the goal of the game is to teach a player something, then there needs to be some sort of structure to ensure that they have seen and understood this information.

On the other hand, there are passive (serious) games. In this type of game, the player is guided through the story line and has a limited amount of chooses (Ferguson et al., 2020). Story structure has often been found important in the context of education. Most noticeable was how important it is for retention and recall of information. Since the player can be more focused on the information that the game will give them instead of being distracted by all the freedom they have. (Serrano & Anderson, 2004) stated that a story structure can have a particularly positive effect on procedural knowledge or skill acquirement. (Shute, 2017) further report that having a narrative element in a game can help with motivation. A good story structure can help with optimal learning and keeping the player engaged and motivated.

Active games give the player the freedom to make their own chooses and can help with spatial awareness and memory. It also helps the player to immerse themselves into the game. On the other hand, passive games help the player to retain and recall information easier since it has a structured story line. Passive games are especially helpful when making educational games since it is easier to guide the patient into learning specific subjects. Therefore, the type of game that will be used is a passive game.

2.2.3. Keeping children interested in a game

Getting children interested in a game can be easy but keeping them interested can be more difficult. It is difficult to find one universal solution for getting children interested, but there are three ways that have worked for most of them.

(Nand et al., 2019) states that there are three key factors in making an engaging educational serious game. These are Challenge, Feedback and Graphic visuals. Using a combination of these three focus points, have greatly improved the learning outcomes of the children. It was found that using one of these three already increases the learning outcome and using them together resulted in the best possible outcome.

(Kyfonidis & McGee-Lennon, 2019) found that having good visuals can help children to understand and remember certain aspects of a game better. The study has found that using visualizations help children retain

the information better, which is an important factor in making games. Which supports the claim that good Graphics help with the level of engagement in a game. The study also found that introducing an interactive aspect into the game can help with keeping the interest in the game. A few parents noticed that their child reacted well with the interactive level of the game. Which further confirms that feedback and some level of challenge can improve the enjoyment of the game. (Jonsdottir et al., 2019). However, they used a VR set up and the game was for rehabilitation. But, using a game gave a sense of fun to an otherwise boring task.

When looking at the above research, making a game using these four aspects: challenge, feedback, interaction, and Graphics could help children be interested in a game and stay interested. One of these points already showed an improvement, so using all four would be the best option while making a serious game.

2.2.4. Existing diabetes games

To get a better view of what kind of games are already out there, three games have been evaluated. These evaluations helped in creating the unique selling point of the game.

MySugr junior

Figure 7 - MySgr Junior

https://mysugr.com/en/ & https://assets.mysugr.com/website/mysugr.com-wordpress/uploads/2016/02/mySugr-Press-Release-Junior-US-Launch_June-7-2013_Jun_7.pdf

This game is specifically made for children. There is an adult version as well. This game can be downloaded in the Appstore and play store. It is mainly a logbook. The children can insert their blood-sugar level and amount of carbohydrates they eat. The app also helps with learning to calculate their medicine and counting carbohydrates.

The app is focused for children between 6 and 10 years old. It is not only useful for the child, but also for the parents. The app can be connected to the phone of the parent where they can see the information from the child. This way they can see what they are doing even though the parents are not near the child.

The app works as follows; the child and parents install the game on their phones and create their own accounts. The child can give the little monster, as seen in figure 7, a name. This monster will encourage the child throughout the process of the app. The child can insert all types of different diabetes related information. Such as blood-sugar level, insulin dose, amount of carbs, notes and the can even take pictures of their food and send it to their parents.

The company that made this game is called MySugr. It is a startup company based in Vienna, starting in 2010. The started with making the MySugr app, which is focused for (young)-adults. They have multiple people with DMT1 working for them. Which gives the company good insights into what DMT1 patients need.

Carb counting with Lenny

http://www.lenny-diabetes.com/carb-counting-with-lenny.html

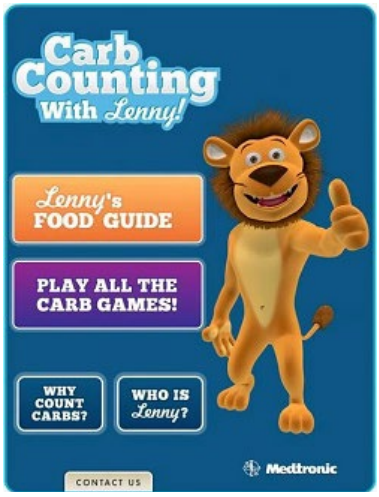


Figure 8 - Home screen

As the name says, this game focusses on learning the amount of carbs in certain food. They have different types of games for this. You have: Carb or no carb? Compare the carbs! Guess the carbs! And build a meal!

Next to this the app also has a food guide. There are not a lot of different foods in the food guide, but they mention the most eaten food by children.

If you are not able to download the app, then you can go to their website. Here you can play all the games that you would on the app. The website also has different types of contests. The last contest was making a video using Lenny. Next to this, they offer information about DMT1. Although it looks like the website has not been updates in some time.

The game is made by Medtronic. Medtronic is the biggest company regarding medical devices. One of their sub companies focusses on making DMT1 devices. The company exist since 1949 and has merged with a lot of other medical companies.

Monster manor

https://ayogo.com/blog/monster-manor/

This app must be connected with Blueloop, which is a Diabetes tracking app. Monster manor cannot do this on its own. The child can insert the information into the Blueloop app, every time this happens the child will get another monster for in their manor. The goal of the game is to encourage children to get a better control over their DMT1.

The parents also have access into different insights and as a reward they can send their children extra points when they think the child did well. The focus group is for children between 6 and 13.

Sanofi developed the app alongside ayogo health. Sanofi makes most of the insulin related products on the world. Just like Medtronic, it makes a lot of different medical devices. Unfortunately, there is not a lot more information about this app. The last update on the websites blog was in 2012.

Figure 9 - Monster manor

2.3 Conclusion

It can be overwhelming to implement all the different aspects found into one app. So, it is important to focus on a few aspects. During the following chapters, it is important to find what the biggest problems are according to doctors, parents and of course the children.

One of the problems that were found during the above chapter, is controlling the disease. Since people have this disease for life and has a big effect on their health, it is important to have a good control over their health and implement some type of structure.

Because of this, it is important to educate the children and the parents well from the moment the diagnose has been made. The average age of the diagnoses is between 6 and 12. Since technology is a big part of the current generation, the focus will be put on serious games. These games do not focus on entertainment and in this case will focus on DMT1 education. The games that already exist for children with DMT1 mostly focused on carbohydrate counting or registering their daily blood sugar levels. Most apps did not involve the parents a lot and often doctors were not involved at all. This would be a good place to start, since it will give the game it is unique selling point. It is also important to involve the parents in the process since they create the structure for the children and will help them with their problems.

The current idea for the game is to implement an easy connection with not only the parents of the child but also for the diabetes specialists. This way it is easy for the doctors and parents to monitor the child. Sometimes a child, and even the parents, can be difficult to communicate with regarding struggles they experience. Using this app will hopefully smoothen the communication gap.

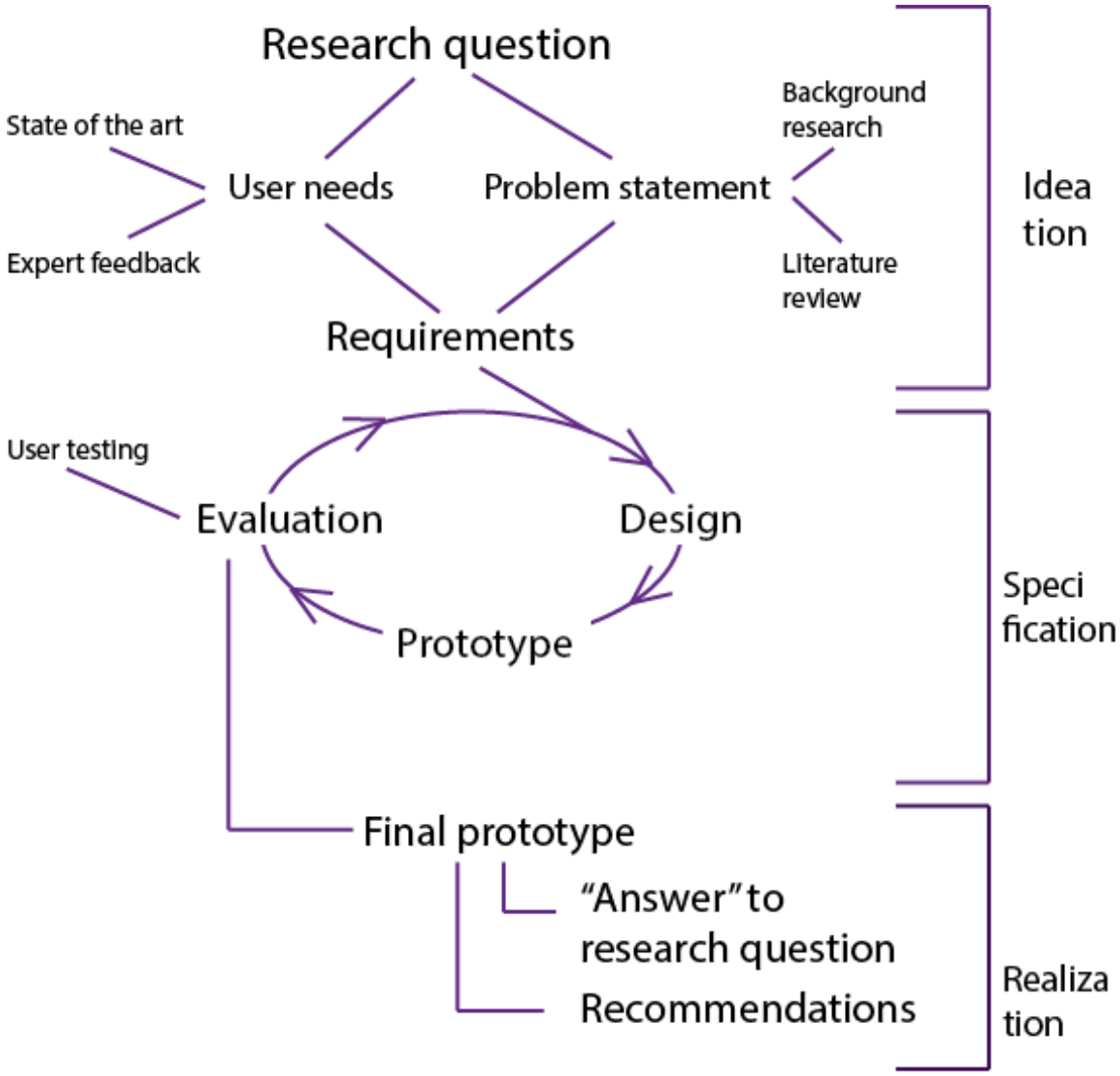
Another point of focus would be to use Challenge, Feedback and Graphics in the game. This has been found to be of great influence on the motivation of children when playing a game. Focusing on passive games would fit a serious game the best, since it creates a more guided storyline in which the creator can easily direct the player to the information they need to see and learn from.

The first idea of the game is an avatar style game, where the children take care of an animal that also has DMT1. Because an avatar is used, the specifics of the game and what they learn can be broad. New aspects can also be added later. Another key aspect will be involving the parents and diabetes specialist in the game. This adds control points between appointments.

Diabetes specialist will be interviewed to see if the conclusion made here about the biggest struggle during the educational period is correct. The other part of the interview will gather feedback about the current game idea and what they think should be included into the game.

3 Method

To get a better idea of the biggest problems that the doctors face during the education process for children with DMT1, more research was done. (Mader & Eggink, 2014) have written an article about the design process for Creative Technology. This design process will be used during the next parts of this project. This method uses three phases: Ideation, Specification and Realization. Their idea of a good design process was changed to fit the type of end design for this project better.



Following the information gathered during this chapter and combining this with Chapter 2, a better understanding of the focus of the game will be found and some initial designs will be made.

3.1 Ideation

During the ideation phase, more information will be gathered in the form of interviews with experts. The information found during Chapter 2 combined with expert interviews gave a better starting point for the

game. Using this information, an analysis has been made. This analysis resulted in a list of requirements, for both the parent version and the version for the child. This list has been made afterwards using the MoSCoW method (The Agile Business Consortium. (n.d)), which then has been ranked from high priority to low priority for this research. The last part of this phase will focus on a first rough iteration to get more insights from parents and children. The first iteration will focus on the different functions that are needed. It is important to do this first, so that the design can be made according to this feedback.

It is important to note that due to the COVID-19 crisis the evaluations could not have been done in person. The best way to do the evaluation would have been to sit down with the participants so that it is possible to see their reaction to the questions and prototype. It could also help to see at which points they have trouble with using the app. It would be recommended to use this method in future work.

3.2 Specification

This phase focusses on the information found during the ideation phase and using this information to make prototypes which then can be reviewed. The first design ideas were made using ProCreate for the iPad. This is an easy way to draw fast and it is easy to send to the computer. Adobe XD will be used to design an interface and create a functional prototype. More information will be shown in the next parts, which have been divided in three parts to get a better overview of how the specification phase will work.

During this phase, two iterations for the parent's version will be made and one iteration for the children.

3.2.1 Design

The design phase shows what the goal needs to be for the next version of the prototype. These goals and functionalities have been generated using the requirements from chapter 4. And in the second iteration, by using the feedback gathered from the evaluation. For the realization chapter, all the feedback and requirements from previous chapters will be used.

3.2.2 Prototype

During the design phase, information and requirements from the previous phase will be used to make a list of required functions and some initial designs. Using Procreate for the iPad for making the sketches, adobe Illustrator for cleaner designs and adobe XD to create more refined and interactive designs.

The prototypes have been used during the evaluations. The final prototype will be made during Chapter 6.

3.2.3 Evaluation

It is important to evaluate during the testing; this way small problems and bugs can be dealt with before a bigger version is made. During the testing sessions with the game, the game will be evaluated on several different aspects. Using the prototype of the app, several questions have been asked to adults and children that fall in the focus group. The first evaluation round focused on the different functions that are needed. The second one focused on the design of the two apps.

The UTAUT (Unified Theory of Acceptance and Use of Technology) has been used during the evaluations to get a more structured and supported evaluation. The UTAUT (figure 11) model uses four constructs that have a

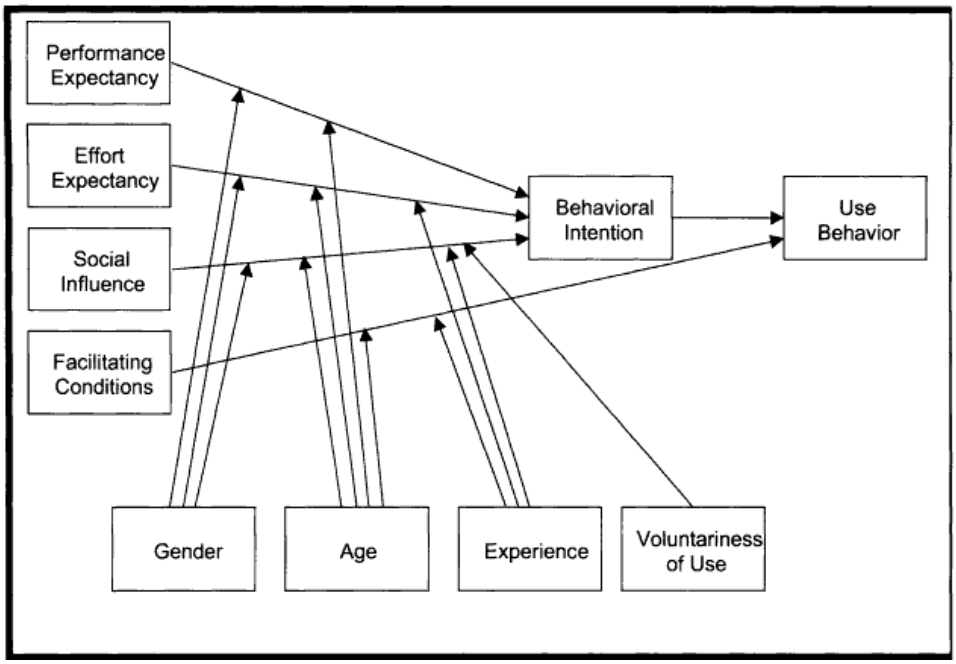


Figure 11 - UTAUT Model

significant role as direct determinants of user acceptance and usage behavior: performance expectancy, social influence, effort expectancy and facilitating conditions. (Venkatesh, Morris, Davis, & Davis, 2003). The questions during the evaluation will be categorized using the UTAUT model.

Figure 12 - UTAUT research model

3.3 Realization

After the previous phase, a final design of the parent version will be made using the information gathered in the previous phase. The design will consist of how the necessary requirements will look in the game itself. It will also show the requirements that did not make it into the game but are necessary for it to work in the way it was intended. And an interactive prototype has been made using Adobe XD and Proto.io.

4 Ideation

The focus of this phase is to analyze the already retrieved information and do further research when necessary about DMT1 and games, but especially interview Diabetes specialists to gain more insight into the educational process for children with DMT1 and what some of the struggles can be. Interviews with Diabetes specialist have been conducted, combining the answers with information gathered about DMT1 and serious games, an overall list of requirements has been made. This is important for the next phase, since it will set the tone for the direction the game will go into and what needs further researching. This information will lead to a list of requirements that is ranked, which can be found in table 5.

4.1 Theoretical framework analysis

To get a better overview of the requirements for the game, two short analysis have been made following the information from chapter 2. The first analysis is regarding the background information from DMT1. The second analysis focused on information found regarding important aspects that need to be included when making a serious game. The conclusion from these two analyses will be combined with chapter 4.2 to generate a final requirements list that will be used during the design process in chapter 5.

4.1.1 Background Diabetes Mellitus Type 1

The information found during the research into DMT1 has been analyzed to generate requirements that are necessary to create a useful game regarding DMT1. During this analysis, the different treatments have been compared. And the multiple ways to control DMT1 have been compared to see where the focus should be on while making the game.

2.1.2 Symptoms, Diagnoses and Treatment

ID	Requirement	Clarification
D1	Give option to choose the way insulin is injected	- Some patients use needles to inject their insulin. - Some patients use a pump to inject their insulin. - Both should be an option when a new account is created.
D2	Give option to choose which type of glucose monitor is used.	- One is the Flash Glucose Monitor (uses a sensor that registers the glucose level periodically). - The second is using direct blood from the finger to measure the blood glucose levels. - The last option is to use a Continuous Glucose Monitor (uses a sensor that registers the glucose level continuously).

2.1.4 Controlling Diabetes Mellitus type 1

ID	Requirement	Clarification

D3	Specifically tailored to patients	Tailoring the program to a specific person has proven beneficial in past researches.
D4	Educate parents	Educating the parents can help the younger children wince they cannot do everything themselves yet.
D5	Educate schools	Educating schools can help the children when they are not under the control of their parents anymore. It can also help with anxiety that the parents experience when their child goes to school.
D6	Structured lifestyle	In several of the previous researches, a structured lifestyle has shown great benefits on the level of glucose control.

Table 3 - Requirements as results of DMT1 background information.

4.1.2 Background Serious games

The information found during the research into serious games has been analyzed to generate a list of necessary requirements. The two important subjects that have been analyzed are the types of serious games and how to keep children interested in games.

2.2.1 Types of serious games

ID	Requirement	Clarification
S1	Create passive game elements	Passive game elements help with retaining information.
S2	Using some type of (structured) narrative	Using a structured narrative can help with motivating a player. A narrative can be translated to a written account of connected events, a story. This means that the game shows a logical structured chain of events.

2.2.2 Keeping children interested in a game

ID	Requirement	Clarification
S3	Use Feedback	Using a well-designed feedback system will help motivate children when they are doing this wrong or right.
S4	Use well designed graphics	Using good colors, design and interface can help in keeping the children interested.
S5	Create challenging aspects.	Challenge is a very important part in games, since it will keep make sure that the player wants to keep trying to complete a task. In this case we mean the challenge of completing

		certain tasks in the game. If the tasks are too easy to complete, a player can get bored.
S6	Use well designed interactions	Interactions are important in apps and games alike. An interaction, in this case, is what types of functions can be interacted with in the game. Is the lay out and result of an action logical.

Table 4 - Requirements as results of Serious games background information.

4.2 Diabetes specialist

The opinions of different diabetes specialist have been examined by conducting interviews. In the early stages, three diabetes specialists have been interviewed and their opinion has been analyzed to get a better understanding of what obstacles diabetes specialist face when treating a patient. The specific interview questions can be found in Appendix I and the transcribed interviews van be found in Appendix II, not all questions have been asked for time sake and the directions some of the interviews followed.

The explanation that was given about the current idea of the game was that it would involve an avatar that the children can choose. This avatar also has DMT1 and while the child takes care of the avatar, they learn more about how to take care of themselves. The game will ask for specific DMT1 information to make the game as personal as possible. The form in which the game will teach the child about DMT1 has not been specifically planned out at this point.

Question	**DS 1**	**DS 2**	**DS 3**
Biggest obstacle	Depends on the age. Transition from parent to child is difficult. Parents do not let go and children are okay with that.	Lack of concentration and are not open in the communication. Children get scared when they must do things themselves. Parents cannot let go.	A lot of information at once and parents often do everything for them. When the transition happens then they can forget things very often.
Education			
- **Focus of the educational program?**	Is being done in steps. Structure is important. And not forgetting a step.	-	Around the age of six, the basics will be taught to the parents. Around 9 the children will learn it themselves.
- **What is missing in the**			Already works well. Also depends on the person. Some need more

educational program?	Communication from parents in the transition stage. Do not leave the children to do their own thing. Help with timing.	Instructional videos are used, which works well. Focus on making something fun for the younger children.	structure and some more practice.
Parents - **Parent's influence on their children.**	Parents have a big influence. Children need help with their education, and it is the task of the parents to help them with it, since some aspects of the education program are too difficult for the child to do on their own. Influence would be good. But not everyone will use this. Focus more on parents and not doctors.	Very big influence. Positive and negative. Some parents have a hard time letting go.	Very big. The basis will be made by the parents. But they need to learn to let things go. Otherwise the child will not be the full "owner" of their disease.
- **Control from the parents and doctors**		Give them constructive feedback. Otherwise it can be interpreted in a negative way.	It will not motivate them if the children know they are being watched. You can implement a reward system, but do not give the parents too much to do.
Game idea	Interesting. Integrating parents and doctors is new.	Would be fun. Interested in seeing if taking care of something else would improve their own life. Encourage them to let them do it themselves first.	Sounds fun, implementing the schedule would be good. But it will be hard to use at school.
Injections or pumps	Injections in the beginning. They transfer to pumps fast.	-	Focus on the pumps since they require more information. And with the pump the children also eat snacks. With only injections this is not needed.
Avatar representing	-	Focus on feeling if that is possible. Make them	

		understand what they are feeling.	
Focus of the game	-	Focus on the reminders and creating structure. Do not implement too much unnecessary functions. If it does not work, then do not use it.	The reminders are very important. And the influence of too much or too little insulin since it can be hard to describe the feeling.

Table 5 - depicts summary of the answers given by diabetes specialists.

One of the hardest things for the parents during the educational process is that they need to learn to let go. At some point the child needs to learn how to deal with the disease. If the parent is too overbearing and does not let the child handle their own problems, the child will expect this for the rest of their lives. On the other side of the spectrum there are the parents that do not understand the disease themselves and do not want to or cannot involve themselves with the disease of their child. It is important to have a good communication line between the parents, doctors, and the children. That is why the transition phase can be the most difficult time for the parents. Implementing a different version for the parents could help with this difficult phase. They have a little more control over their children when they are not at home and they do not have to constantly ask the child how they are doing with the learning process. Parents (mental) health has a big effect on the wellbeing of their children (Helgeson, Becker, Escobar, & Siminerio, 2012). Their anxiety regarding life and the DMT1 of their children influences their children. This is one of the reasons to implement the parent version of this game. The version for the parents will focus on the input of the data for their child and keeping track of their progression with the different subjects that are being taught in the children version of the app. So, since the involvement of parents in the game has a high priority and because this is one of the unique points of the game, the design process in the following chapters will focus on the parent version of the game.

Another important factor to focus on while making the games is structure and reminders. The Diabetes specialist have all three stated that children can easily forget to do things. This can be the cause of different things. It could stem from them being forgetful. Lisa Kutcher stated that it could stem from a lack of concentration and communication. This becomes a bigger problem when they enter puberty. Another thing she stated was that some children may be scared to start doing things on their own. In the beginning their parents will help them with injections etc. but at some point, they must do it themselves. Not knowing what to do can have a negative effect on them even more so when they are too scared to ask for help.

Depending on the age that the child receives the diagnoses of DMT1, the amount of information can also result in a lack of motivation Jolene van Ernst stated. Around the age of 9, is when the children will have to learn the basics themselves instead of their parents. This can be a lot to take in, for both the child and parent. This can result, not only in a lack of motivation but also in forgetfulness since the child (and parents) are not used to the new lifestyle yet.

4.3 Requirements

From the above analysis the following requirements have been formulated. With these requirements, the general direction of the game has been made. Using this, design sketches can be made during the next phase.

To make a clear ranking of the gathered requirements, the MoSCoW requirements ranking was used. (The Agile Business Consortium. (n.d.).) The requirements ranking was rated as follows: 'M' (Must have), 'S' (Should have), 'C' (Could have) and 'W' (Will not have). This rating system for the requirements generated a list of requirements that will be used during the next few chapters of the research.

4.1.1 Background DMT1

ID	Priority level	Requirements
D1	M	Give option to choose the way insulin is injected
D2	M	Give option to choose which type of glucose monitor is used.
D3	M	Specifically tailored to patients
D4	S	Educate parents
D5	C	Educate schools
D6	M	Structured lifestyle

4.1.2 Background Serious Game

ID	Priority level	Requirements
S1	M	Create passive game elements
S2	C	Using some type of (structured) narrative
S3	M	Use Feedback
S4	M	Use well designed graphics
S5	S	Use Challenge
S6	M	Use well designed interactions. The interactions with the app and the results from an interaction need to feel logical. (such as: when a press the button that says 'BACK' the app reacts with switching to the last used screen).

4.2 Interviews Diabetes Specialists		
ID	**Priority level**	**Requirements**
I1	M	Create structure in their life
I2	M	Consistent reminders
I3	M	Create version of the game specifically for the parents. The app will focus on analyzing the child's behavior in the game.
I4	M	Use constructive feedback for both the parent's app and the child's game.
I5	C	Try to teach them wat certain feelings mean
I6	M	Reward system that the parents can use.

Table 6 - Requirements gathered from previous analysis. M = Must have, S = Should have, C = Could have. D = DMT1 requirements, S = Serious games requirements, I = Interview requirements.

From the above list of requirements, a new list of requirements has been made focusing on only using the requirements rated as 'M' (Must haves). This list is also then ranked from which requirement will have the highest possibility of being integrated into the first versions of the game. This is a result of the large amount of time it takes to implement all the above requirements. However, the requirements rated 'S' and 'C' should be taken into consideration when/if more research is done into making the game.

Rank	ID	Requirement
1	I1 & D6	Create structure in their life
2	I2	Consistent reminders
3	I3	Create version of the game specifically for the parents. The app will focus on analyzing the child's behavior in the game.
4	D3	Specifically tailored to patients
5	D2	Give option to choose which type of glucose monitor is used.
6	D1	Give option to choose the way insulin is injected
7	S3 & I4	Use constructive feedback for both the parent's app and the child's game.
8	S6	Use well designed interactions. The interactions with the app and the results from an interaction need to feel logical. (such as: when a press the button that says 'BACK' the app reacts with switching to the last used screen).

9	S4	Use well designed graphics
10	S1	Use passive game elements
11	I6	Reward system that the parents can use.

Table 7 - Ranked list of 'Must have' requirements. D = DMT1 requirements, S = Serious games requirements, I = Interview requirements.

The above table has been ranked with the focus being based on the game. Such as, what should be the focus of the game, who will be the users and what types of interaction are the most important in the current phase. When the basis has been put down and tested, the focus can be shifted to the overall look and feel of the app and the programming of the actual game.

4.4 First iteration

The first iteration will focus on how the requirements translate into the functions. The prototype that will be made will focus on what types of functions and interactions should exist in the app. For the parent and the child version. During this and the previous chapters, an idea for the game has been generated. The game is played by using an avatar. The child can choose an avatar that will represent them in the game. The goal is to take care of the avatar. Since the avatar also has DMT1 it will remind the child to do certain tasks at certain times. With a focus on measuring their blood glucose level and injecting the right amount of insulin. The game will send reminders through notifications. If the child is doing well, it will get achievements and new outfits. The parents have their own version of the game. They can insert information about daily eating and insulin schedules and edit this when things change. They can also see different summaries about how much the child reacts to the reminders that are send and they can see how long they use the app. This will help with seeing where the problems lie and communicate this to the Diabetes specialist.

During this chapter different versions of designs will be made using the requirements from chapter 4.3. The requirements will be divided in different groups to get create a more structured design process.

4.4.1 Parents

This iteration focusses on getting more information on the different types of functions that should be included in the prototype.

4.4.1.1 Design

Using the MoSCoW requirements gathered in chapter 4.3, a list of functions and goals is created.

Parenting children with DMT1 can be a difficult task, since it requires a lot of extra work for both the parent and the child. There are three different factors in parenting children with DMT1 that experts have found to be the most important: control, involvement and affection (Harris, Mertlich, & Rothweiler, 2001). The research done by (Harris et al., 2001) has also found that the level of influence from these factors should change throughout a child's use for it to still be beneficial. Often all three of the factors start high when the child is still young, but involvement and affection levels drop the older the child gets while control still stays

high. Having the parents be more involve with their children's DMT1 has shown an increase in control over their blood glucose. This was due to the parents encouraging the children to measure their blood glucose levels more often (Anderson, Ho, Brackett, Finkelstein, & Laffel, 1997).

During the research done in the previous chapters it was found that implementing an eating and insulin injection schedule into the app with timed reminders would be the most beneficial for the improvement for the structure in the children life. Combining this with the need for personalized versions of the app, the functions that the parental app should include became clearer. The goals can be found in table 8 below.

Goal	**Function**	**Sub-goal**
Structure	Schedule	Daily routine Reminders for insulin injections Eating schedule
Personalized	DMT1 information input	Type of insulin injector Amount of insulin needed Type of blood glucose monitor Sensitivity
Involvement	Summary	Usage of the game Reaction to reminders
	Rewards	Send reward points to the child's app when the parent finds it necessary

Table 8 - Functions, goal, and sub-goals for parents' version.

These functions, goals and sub-goals will be used to make the app for the parents. The sub-goals will be used to gather all the necessary information that is needed for the child's game to function to its full protentional. The design of the app will be quite simple since the goal for this version is to help with control and involvement.

4.4.1.2 Prototype

Using the goals from table 8, functions and sub-goals a very quick with sketch has been made. This sketch will be used as a general outline for the version that will be made in Adobe XD.

To keep the information that the parents fill out save, an account is needed. Just an email address and password will work. This also makes it easier to transfer the data from the parent's app to the game of the child. Some general information needs to be filled in such as their name age and gender to make the messages used in the children version more personal. When this is filled out more specific information about the child's DMT1 is needed. Which type of insulin injector they use and what type of glucose monitor they use is important. This will change certain comments in the children's version of the app and the evening reminder changes depending on which of the two injectors is used. The insulin ratio needs to be filled in if the use needles or a pump, but the sensitivity only needs to be filled in when the child uses a pump.

After all the DMT1 information is filled out, the parent needs to fill put the schedule the child usually follows. There is one screen for weekdays and one for the weekends. The need to fill out the starting time and the end time of when the child eats breakfast, lunch, and dinner and when they usually go to bed. After all the information is filled in, a conformation screen is shown to make sure all the information is correct. If not, the parent can go back to change this.

After the parent has completed to create an account process, they will continue to the next screen. This screen is also shown when the app is starts up for regular use. The menu lest the parent choose which type of information they want to see. They can also choose to edit the child's information, since this can be a regular occurrence shortly after the diagnoses has been made.

The first option shows the amount of times a child has reacted to the push notification which contains the reminders. These will be sorted into 'B' breakfast, 'L' lunch, 'D' dinner and 'S' time they go to bed.

The second options will show the amount of times the app is used per day. The older data will be saved, so there is the possibility to switch between weeks or change the settings to a month.

After gathering enough data, summary graphs can be generated to get a better overview of certain trends. These statistics will help the parent in recognizing patterns. Such as when the game is not used much, they can easily ask their children why and find a way to fix this.

To let the parents, feel more involved into the child's game, they can hand out rewards when they see fit. The rewards will be shown as points with which the child can buy new customizations. This way the child and parent would feel more motivated to use the app. Designs for these rewards will be produced after the first round of evaluations. The sketches for the first design can be found in Appendix III.

4.4.1.3 Evaluation

It is important to evaluate during different parts of the project. With the prototype made in the previous chapter an evaluation was done. The goal of the evaluation is to see if the global idea of the app works and if adding reminders, a schedule and rewards would be beneficial. Another goal is to see if there are certain

functions that are missing. With the results from this evaluation, new designs can be made. Due to some unforeseen circumstances, it was not possible to meet the participants in person. To still get feedback, an google form was made and send to the parents. The information used to create the form can be found in Appendix IV.

Participants

The evaluation has been done at de Hoeksteen. It is a primary school where a small group of teachers participated in answering some questions. Below is a table where a little more detail is described about the teachers, without hurting their privacy. Due to some unforeseen circumstances, additional participants were needed. Since this part of the evaluation focusses on the functions, it is not necessary for the participants to have children with DMT1.

ID	**Gender**	**Age**	**Children**	**Owned technology**	**Technology usage**
A1	Male	31-35	0 → Is a teacher	Smartphone	A lot
A2	Female	50+	2 → Both 12	Smartphone	Often
A3	Female	50+	2 → Both 21+	Smartphone	A lot
A4	Male	50+	2 → both 21+	Smartphone	A lot

Table 9 – Personal information participants evaluation adults 1

Feedback

First the information that is needed is if the current idea for the parent version of the app is a good idea and if the participants think if it will work and be beneficial. According to the participants creating a schedule for the children is very beneficial. Adding reminders to do certain tasks would also be useful according to the participants.

The next important part is the insights the parents get when looking at the data that is gathered from the child's app. They found it very useful to see how many times the child uses the app. Two participants found it very useful to see how many times the child reacted to a notification. One participant was neutral about adding this option. And all three participants thought that being able to send reward points to the child would benefit the child.

One of the participants added a comment saying if it were possible to add function that could show other people what hypo's and hyper's are and what they can do to help. This is something to be investigated when there is more time.

4.4.2 Children

In this chapter the children's iteration will be designed and a prototype will be made, which will be evaluated.

4.4.2.1 Design

Using the requirements from previous chapters has resulted in a list of functions, goals, and sub-goals for the version for the child. This list contains similar information as the list in chapter 5.1.1 since these goals are the main goal of both applications. The list has been edited since the way the game will work is a game and not an information-based application like that for the parents.

When we look at the requirements generated in chapter 4.3 there are some requirements that have an 'M' priority which will be used to generate the goals in this list. Not all the functions will be implemented in this iteration, but they will be used in further chapters.

Goal	**Function**	**Sub-goal**
Structure	Schedule	Daily routine Reminders Eating schedule
Personalized	DMT1 information input (Done by the parents) Choose an avatar	Type of insulin injector Amount of insulin needed Type of blood glucose monitor Sensitivity Personalize the avatar (using reward points) Pick a name
Incorporate passive game elements	DMT1 related	Insert blood sugar level. Insert amount of carbohydrates for a meal. Calculate amount of insulin needed.

Give feedback	Pop-up messages	Positive feedback to completion of a task Constructive feedback to failed task Rewards for repeatedly doing a good job Message when the avatar needs something (food, water etc.) Show advice when blood sugar is too high/low

Table 10 - Functions, goals, and sub-goals of children version.

The next step is to create a list of more specific functions to play the game. To create this list, examples have been compared to see which functions are most common and would fit this design idea the best.

	Tamagotchi (1996)	**Nintendogs (2005)**	**My Gu (2015)**	**Petz (2006)**
Hunger meter	Yes	Yes	Yes	Yes
Thirst meter	No	Yes	No	Yes
Happy meter	Yes	No (Happiness depends on other factors.)	Yes	Yes, Divided in love and energy
Toilet	Yes	Yes, when doing walks	No	Yes
Discipline meter	Yes	Yes, training possible	No	Yes, can run away
Health/ cleanliness	Yes	Yes	Yes	Yes
Age and weight check	Yes	Do not age. Can get overweight	No	No
Uses credits	No	Yes	No	No

Can get sick	Yes	No	No	No
Customizable	No	Yes	Yes	Yes
Mini games	Yes	Yes	Yes	No

Table 11 - Comparison of avatar style games

From table 11 a list of necessary functions for the game has been made. These must be relevant to the goal of the game, so there should not be too many functions that can distract the player from the educational goal of the game. How these functions will be shown in the game will be researched later. But most speak for themselves.

Using the information gathered above, a list of functions that are necessary for the game to work well and function was made. This information was gathered using examples of other avatar style games in the previous chapter. In table 12 the functions are ranked from most used, to less used in the examples. These functions will be implemented in the second iteration.

Rank	Function	More information
1	Hunger meter	Food needs to be given to the character for them to stay alive on a regular basis.
2	Happiness meter	This meter will go up when the child plays with the character. For instance, letting the character play with a ball or bone.
3	Health/cleanliness	A brush will make them cleaner.
4	Customizable	Giving them clothes to wear, or change the background of the room they are in.
5	Toilet	For dogs this could be taking them outside, for the cat it would mean changing the kitty litter.
6	Mini games	Will not be added to the game. To make sure that the focus stays on the DMT1 tasks.

Table 12 - Ranked functions

4.4.2.2 Prototype

Sketches for the interface can be found in Appendix V. When the child logs into his/her account (with the help of their parents). They have the option to confirm their information, to make sure they have the right

account. The next step is to choose which avatar they would like to use. Since the child gets to choose their own avatar, multiple different types of avatars need to be made. To give the child multiple options and not focus on one gender or interest, four different animals will be designed. A rabbit, cat, dog, and dinosaur will be designed for the game. Sketches for this can be found in figure 12. The child will also get the option to give the pet a nickname, which will be used in pop ups and other interactions.

Since a working prototype is not needed for this iteration, this chapter is relatively short. The look of the game will be designed during the next iteration.

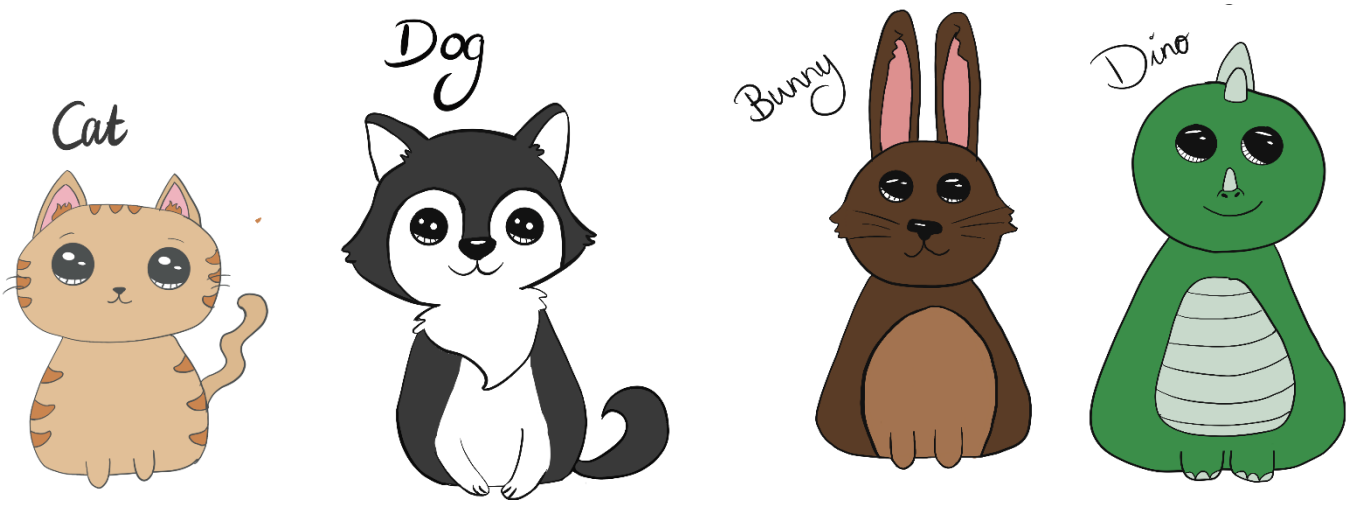


Figure 13 - Sketches of avatars.

4.4.2.3 Evaluation

It is important to evaluate during different parts of the project. As mentioned before, the focus of this version is on the functions that are necessary for the game and to see what types of games the children like to play the most. This can be used to extract some functions they contain that may benefit this game. Due to some unforeseen circumstances, it was not possible to meet the participants in person. To still get feedback, an google form was made and send to the parents. The information used in the form can be found in Appendix IV.

Participants

The evaluation has been done at de Hoeksteen. It is a primary school where a small group of children participated in answering some questions. Below is a table where a little more detail is described about the children, without hurting their privacy. The parents of all the children have given their consent into letting their children participate. Since the focus of this evaluation is to see what types of functions are necessary for the next and final version of the game, it does not matter that the participants have DMT1. Some other questions will focus on what types of games they like and why they stop playing a game or keep playing a game.

ID	Gender	Age	Owned technology	Technology usage (a day)
C1	Male	10	Phone and shared iPad	1 hour
C2	Female	11	Phone and shared iPad	1 hour
C3	Female	12	Phone and Chromebook	2 hours
C4	Female	8	Phone and iPad	More than 3 hours

Table 13 - Personal information participants evaluation children 1

Feedback

First some extra information about the medium the children used. All the participants have their own phone and most use this to play games on. Some have an iPad they use to play games. The types of games they play and apps they use the most were all different accept that two of the participants used tiktok.

It was clear that avatar style games were a good choice according to the participants. From the four options that the participants could choose from, the bunny was clearly the most liked. There were also some suggestions for other animals such as a chimpanzee, pony, and a jaguar.

Earning points during the game was found as beneficial to the experience. There were some suggestions for what the points could do in the game. The most suggested options were to buy some new accessories. Some examples were: new toys, a new home and new food.

5 Specification

As mentioned before, two versions for this app will be made. A parent version and a child version. This results in two different iterations. To do this, a list of functions that need to be included in the prototype will be made. Once the prototype is finished, an evaluation session will be held to get feedback for the parent's version. This feedback combined with the already gathered knowledge from previous phases will result in a final iteration for the app the parents will use, which can be found in chapter 6.

5.1 Parents

5.1.1 Second iteration

The second iteration will translate the functions into a design. While taking the feedback from the previous chapter into account.

5.1.1.1 Design

When looking at the feedback that was given during Chapter 5.1.1, the general idea for the app and the functions that were evaluated worked well. For the next iteration it is important to combine the functions/requirements with the design.

It is important to integrate the functions that are needed for this app to work the way it was intended. If we look at the feedback, we can see that all the functions are useful and should be used in the app. Some functions have been removed according to received feedback.

Goal	**Function**	**Sub-goal**
Involvement	Summary	Usage of the game Reaction to reminders
	Rewards	Send reward points to the child's app when the parent finds it necessary

Table 14 - Reviewed functions parent's app

A bigger version of the list above is also used in Chapter 5.1.1.1, but a small change has been made. Since there will be no mini games in the app of the child, this section has been removed from the parent's app as well. This list is smaller since these are the functions that will be used in the app. The other functions are only focused on the sign-up phase for the account.

To create a good looking and easily usable app, there are some design choices that need to be made. These choices have been split up in different sub choices. Below is a table containing these sub choices and what the focus should be.

Interface	General interface Menu
Color & fonts	Color scheme General font Bolder font
Graphs	App usage Reactions to reminders

Table 15 - Design choices

During the next chapter, prototypes from these design choices will be made that can be used to evaluate.

When we look at the feedback given by the children and the parents regarding the rewards, we can make some changes to how it should work. Since most children want to spent have different types of rewards, it would be a better idea to give the parents the option to send their child points. The children can then spend these points in their own version of the app. children can also earn points on their own. This part will be further researched and designed during chapter 5.2.2.

5.1.1.2 Prototype

Using the functions generated and evaluated during the first iteration, sketches for the app have been made. These give a quick overview of the different screens that are required for the final version. These can be found in Appendix VI. The sketches consist of the “create an account” screen following with what the parents will see when they are logged in. These sketches have been translated in a working version to see if the flow of the app is logical when it is used. The flow and interactions that are possible with the app can be found in Appendix VII.

When a parent notices that their child has been doing better regarding the usage of the app or regarding controlling their DMT1, they have the option to send the child some reward points. The parent can choose how many points they send to the child, but they can only do this twice a week. Otherwise the possibility exist that the child earns a lot of reward points fast and it will lose the effect of motivating the child. How the children can spend the points can be found in a later chapter.

The goal of the app is to be informative, therefore there is no real need for over the top designing. The focus should be on the functionality. In Appendix VIII, a sketch for the menu and the general interface can be found. These were used as a base for the design made that can be seen in figure 13 and figure 14. The color of the design only shows the value of what the color that we would pick would look like.

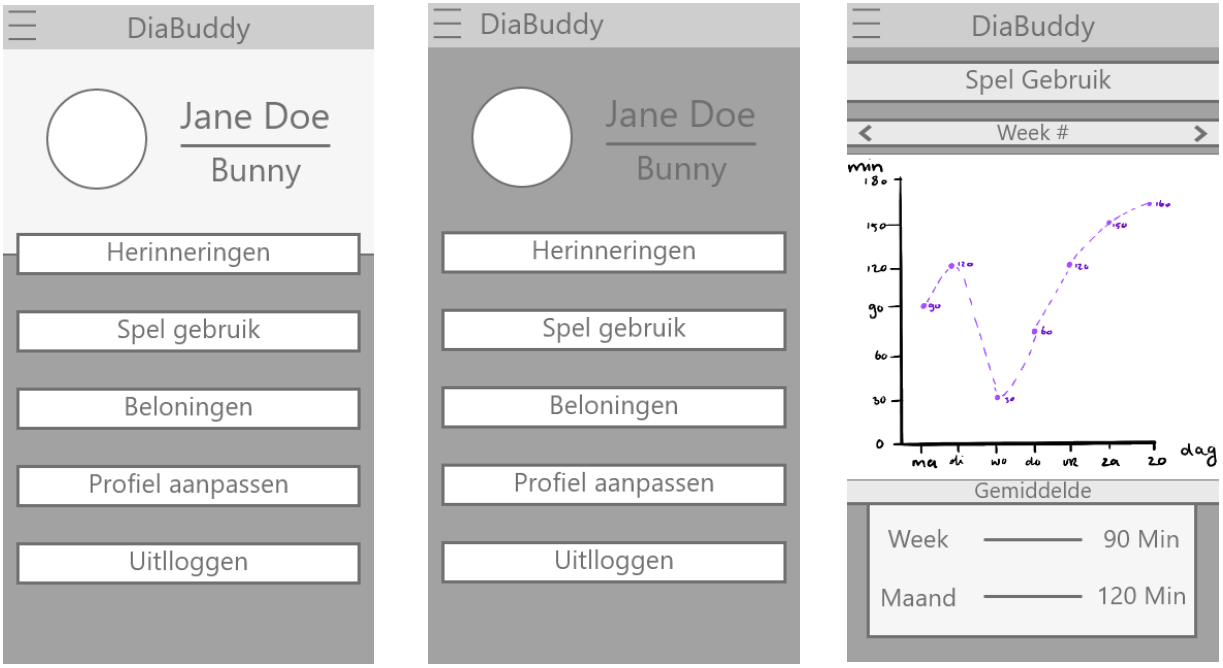


Figure 14 - Interface design 1

Figure 15 - Interface design 2

Another important part for this specific design is the type of graph that is used and the dimensions for the x-axis and the y-axis. These should be easy to understand and clearly visualize the information. In figure 15 and figure 16 two options for the look of the graph can be found, with some variations on the two different designs. These will be implemented for visualizing the game usage and the reaction on reminders. The color of the graphs will correspond with the overall color of the app.

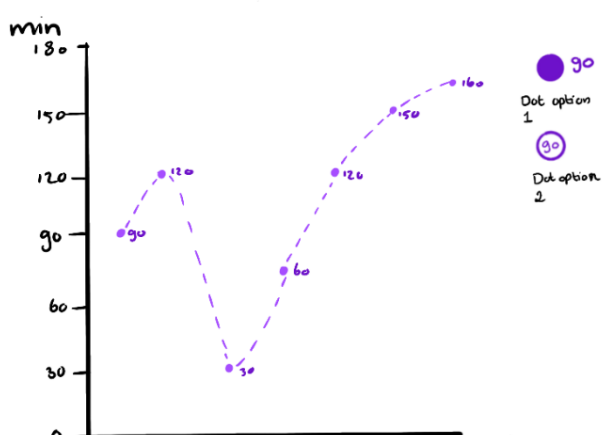


Figure 15 - Line graph

This is a line graph. For the x-axis, the days of the week have been used. The y-axis shows the number of minutes the app is used. Showing it in minutes helps with accuracy. For now, it only says which day it is, but another option could be to use the actual date in this axis. Something that could also be included is the change to change from a weekly overview to a monthly overview when the app is used for a longer period.

Another option for this graph is the difference between a filled in dot with the number next to it, or an open dot with the number inside.

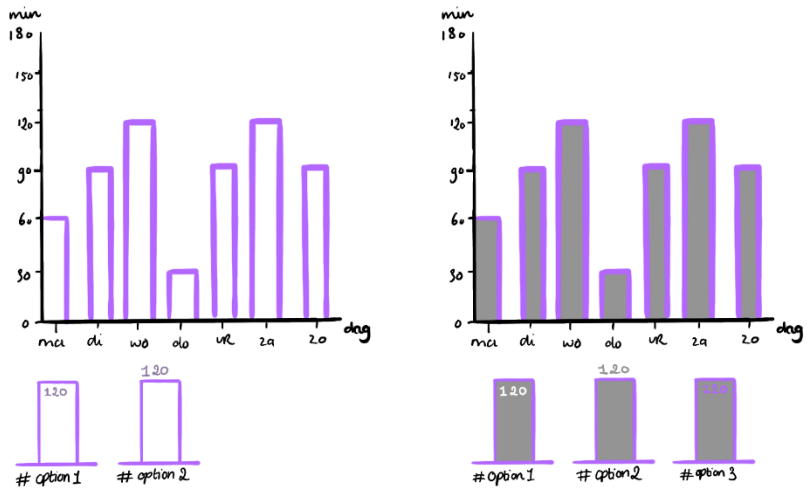


Figure 16 - Bar graph

Another option is using a bar graph. For this graph there are two options. Using only the outline or also filling it with a color. Depending on the look and color for the rest of the app, a choice can be made to fit this the best.

Another choice that could be made is if the bar should touch each other or of they should stay separate as seen in figure 16.

For the placement of the number there are also different options. It could be placed inside the bar or above the bar.

When looking for a color scheme that can be used, it is important to look at what kind of app it is and what type of feeling you want to give the people that use the app. There are three different types of schemes that can be used. Monochromatic schemes are easy to create, the originate from one base color. They go well together because of this and can create a soothing effect. Another option is analogous. This means that one color is chosen, and related colors are used to enrich the scheme. The last option is complementary. Complementary colors are opposites of each other. They are a good choice for drawing attention to certain aspects. Especially when green and red are used together (Babich, 2017).

Since the goal of the app is to give health related information, the color scheme should represent some sense of calmness and not be too saturated to distract the user. Using green or blue colors give the sense of calm

and health. Incorporating this with either monochromatic or analogous, will give the desired result for the app. In Appendix IX, the color schemes can be found that will be evaluated. To create the color schemes coolors.co was used.

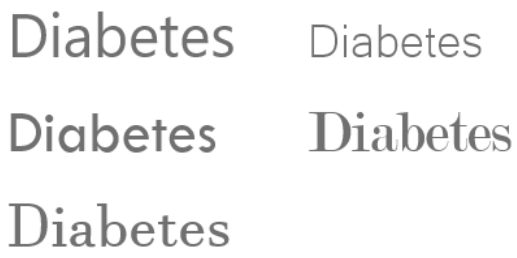


Figure 16 - Different fonts

The next part that is important for the design is the use of fonts. In this case it should be simple and not draw too much attention away from the function of the app. In figure 17 the options for the fonts can be found. Like the other parts of the design, the font should be easy on the eyes and not take focus away from the function of the app.

For the final design different variations of the font will be used. Such as bold, italic, and light. This depends on what function that text has.

5.1.1.3 Evaluation

This iteration focusses on the design of the app that would fit the function the best. In the previous chapter, every sub-group of design has different options that could be used in the final design. These will be used during the evaluation. And will be combined with the functionality in later chapters.

The questions can be found in Appendix X. These questions were categorized using the UTAUT model. Some extra questions were used to get feedback on the design.

Due to unforeseen circumstances, it was not possible to evaluate in person. Therefore, a google form has been made to still get the feedback that is needed.

Participants

The participants have been recruited via Diabeter. This is a specialized Diabetes facility with a focus on children. Since some of the questions are DMT1 related, it was important that the participants know what DMT1 is. The form has been sent to people that were willing to participate. Four people have participated during the evaluation.

ID	**Gender**	**Age**	**Children**	**Earlier participation**
A3	Woman	56-60	2 → 13+	Yes
A4	Man	56-60	2 → 13+	Yes
A5	Woman	46-50	2 → 0-6 and 9	No
A6	Woman	46-50	2 → 12 and 13+	No
A7	Woman	31-35	3 → 0-6	No

Table 16 - Personal information participants evaluation adults 2

Feedback

To keep the information from the evaluation easy to follow, this chapter has been divided into chapters which relate to the types of questions that have been asked.

Performance expectancy

For this part of the evaluation, all the questions were answered between neutral and fully agree. This means that the parents expect to have some type of positive influence on their child and on themselves. The result would be that the app will help in creating more structure and help them remember to inject their insulin and measure their blood sugar levels. The adults also find the reward system useful and a good addition.

Effort expectancy

The information from this part of the evaluation was also rated very positive. The app is logically made and should be easy to use according to the participants.

Social influence

Most of the participants would recommend using this app. One saying they fully agree, two saying they agree and the other two have a neutral opinion about it. It is not clear why they choose this option. They also think that their family would find using the app useful. When we look at the question about if they expect their children to use the app, the answers vary a little. Two agree that their child would use the app, two are neutral and one disagrees with the statement. It is not very negative, but it is something to consider for the next evaluation to see what can be done to make the answers more positive.

Behavioral intention

The goal of the app has been found useful and an overall good idea. The participants find using the app, interesting. The answers to the statement 'I would use the app often' has been answered with mixed reactions. One person agreed with the statement, three reacted with neutral and one disagreed. This is not necessarily a problem since the goal of the app is for the parents to have more insight into their child behavior. Depending on how much insight they want, the amount of times the app is used changes.

Use behavior

A more specific question about the amount of times they would use the app has been asked here. The average answer to this question is a couple of times per week. Four of the participants agree with the fact that they would use the reward system and one is neutral on this statement. This is positive for the goal of the app since the reward system is also a big part of the children version of the app.

Design

The answers to the design questions were diverse. But for every question there was a favored design. These will be used for the next iteration of the app and the final design. In the table below a small overview has been made of the design options and which came in second when this is necessary.

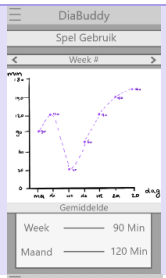
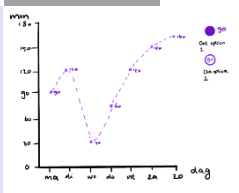
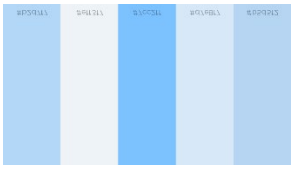
Question	1st choice	2nd choice
General interface		
Menu interface **(For this one the opinions were very different. Therefore the 1st choice will be used as the base. The other designs will be used as a secondary inspiration.)**		
Graph design **(This graph was favored for both the types of data that will be shown.)**		
Color scheme **(Both these schemes had the same number of votes.)**		
Font	Diabetes	Diabetes

Table 17 - Results design evaluation parents 2

This feedback will be used to create a new version of the parents app.

5.2.1 Third iteration

For the third and last iteration of this chapter, all the feedback from the previous chapters will be combined to create a final prototype. This can be used to test the app to get some final feedback. In this case, only the parent's app will have a third iteration. This is since the parent's version of the app is the focus of the project and has the unique selling point for this prototype.

For this version of the app, the focus will be on integrating all the previous feedback and resolve some issues that may have occurred. Another look will also be taken to at the way the data is shown and how the rewards are used. Since this is the main goal of the parent's app it is very important.

5.2.1.1 Design

The feedback that we gathered from the current prototype was overall positive. The goal of the app is clear and has been found useful. This means that the current prototype can be improved rather than changing some of the functions that are already in place.

The design will be changed using table 17. Table 17 shows the favored choices from the evaluation, these will be used for the next prototype. A feature was added. This feature gives the parent the option to choose the intervals with which the reminders are send. The choices are: 5, 10, 15 and 20 minutes.

The most favorable data visualization from the evaluation is the line graph. The version that is in the current prototype is very simple. A new and more detailed version should be made for the next prototype. A list of functions that should be added to the visualization can be found below in table 18.

Priority	**Goal**	**Function**
1	Link to rewards	1. Show pop up message to send rewards. 2. Button to go to rewards page.
2	Better overview	1. Monthly few. 2. Weekly view. 3. Reaction to reminder per day. 4. Reaction to reminder per daypart. 5. Usage in minutes. 6. Usage in hours.
3	More structured rewards	1. Reacted to # reminders. 2. Used for # hours per week.

Table 18 - Graph functions

The reward system is a useful function for this app. This is shown by the evaluations and the feedback from Diabetes specialists. It would be better however, to link the data visualization with the reward system. So, either there is an immediate option to jump between these two screens or generate an automatic pop up message saying that they can choose to send points to their child. Either way, sending the rewards is important for the motivation of the children. So, making sure that this works well is a priority at this point.

5.2.1.2 Prototype

In figure 16 a new and more detailed design for the graphs have been made. The graph was updated according to table 26. This graph is not functional but will be added to the prototype to show what the finished product would look like. The first one shows an example of amount of times reacted to the reminder per day. The second one shows the minutes per day the child uses the app.

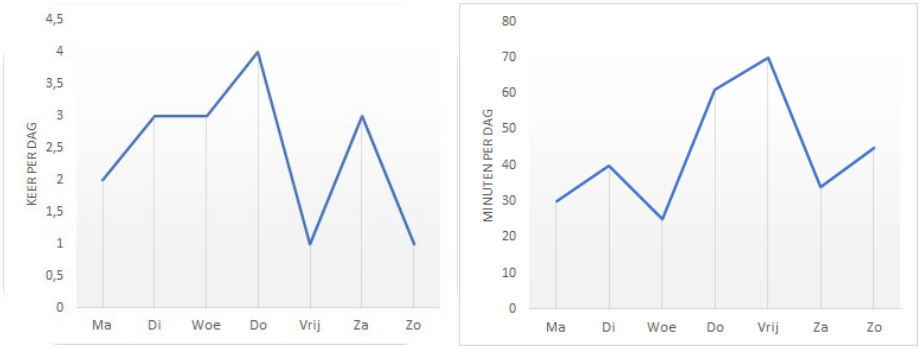


Figure 17 - New design for the graphs

Table 26 combined with table 17 has generated a new prototype. The new look for this prototype can be found in figure 17. This figure shows some of the designs. The flow of the app and all the pages can be found in Appendix XI.

Figure 18 - New interface design

For the reward systems, two options were designed. The user can either go to the rewards menu from the start menu or press the reward symbol while using the graphs. Or a pop-up will appear when a child has reached a certain goal. The parent can then decide if they would like to send these points. In figure 18 the design for these two pages are shown.

This prototype will be used for the final evaluation of the app.

Figure 19 - Design reward system

5.2.1.2 Evaluation

This evaluation is the last evaluation done for this prototype. With the feedback from this evaluation a final version will be made, and a final list of requirements will be generated. The focus of this evaluation will be put on usage of the app and seeing if the users still find something missing. It will also focus on seeing if changes should be made to the current list of requirements. The questions can be found in Appendix XII.

Participants

The participants have been recruited via Diabeter. Due to the lack of time, some participants have been approached personally. This is a specialized Diabetes facility with a focus on children. Since some of the questions are DMT1 related, it was important that the participants know what DMT1 is. The form has been sent to people that were willing to participate. Five people have participated during the evaluation.

ID	**Gender**	**Age**	**Children**	**Earlier participation**
A3	Woman	56-60	2 → 13+	Yes, 1 and 2
A4	Man	56-60	2 → 13+	Yes, 1 and 2
A8	Man	56-60	3 → 9, 13+	No
A9	Woman	56-60	1 → 13+	No

Table 19 - Personal information participants evaluation adults 3

Feedback

The overall feedback from the participants is very positive. There were no participants that have disagreed with any of the statements that can be found in Appendix XII. This means that there are no problems with the goal and functions of the current prototype. Since there are no outliers it is not beneficial for this part of the research to address them all separately. Since the feedback was overall very positive, we can assume that there is a big need for this type of game/app.

In this version some open questions were added. This was done because the participants could add feedback and give a more detailed explanation about what they think of certain aspects of the prototype. The reactions to the open questions will be listed in table 20. From this, new functions will be added, removed, or recommended for future work.

Participant ID	**What types of functions would be useful and beneficial for you? (That are not in the prototype yet)**	**What do you think about the fact that the application asks for personal information?**	**What do you think about the fact that the app is made personal for your child?**
A3	Add a function to see how much additional insulin the child needed.	Fine.	Good idea, giving them their own responsibility.
A4	The color is very light blue. Maybe give the child the option to choose this color. Or change it according to gender.	Not a problem if it useful.	You are never too young to learn. (Jong geleerd is oud gedaan)
A8	Period overview.	-	A must.
A9	-	If it is properly secured, then I see no problem with it.	Good idea. But is the game shareable with other children? Can the play it together without a competition element?

Table 20 - Reactions to open questions

There were some additional notes from the participants. A4 suggested to add an option for the parents to select their own avatar. This does not add anything functional to the application. But it will help with making the parents version more personal. Another commented that I looked professional.

5.2 Children

The second iteration of the app for the children. This iteration focusses more on the design and uses the feedback from the previous chapter. The prototype will be evaluated.

5.2.1 Second iteration

5.2.1.1 Design

When looking at the feedback from the last chapter, we can conclude that the avatar style game is something that children would enjoy. It also showed that the bunny avatar was the favorite and that the points system was a good idea when they could spend the points on new accessories for their animal or room.

To get a better overview of the necessary components for this iteration, table 18 is made. The contents of the table will be split up in easy to research parts. The parts that were not included were focused on DMT1 which will be implemented during chapter 6.

Sub-chapter	Function
Personalization	Choose an avatar Choose a nickname Use points for accessories
Feedback	Reward message Needs message (hunger, dirty etc.)
Game elements	Feed Play Clean Sleep Water Buy menu
Schedule	Eating schedule Reminder message

Table 21 - Necessary components

Personalization

Personilization is a big focus point of this app since it will set it apart from the already made application for teaching DMT1. There are three ways to personalize the app if we exclude the DMT1 related functions.

First off, all the child will be able to choose between four different types of animals. The four animals will be: a bunny, a dog, a cat, and a monkey. In the first designs there was a dinosaur, but it is quite difficult to get a nice design for this. The monkey was suggested by a participant and is easier to design.

To make it even more personal and fun, the child can choose a nickname for their animal. This nickname will be added to pop up messages or notifications when this is necessary. Hopefully, this will help the child get the feeling that it is their animal and that they need to take care of it.

Lastly, the children can earn points. These points can then be used to buy new items for their animal or for their room. In table 19 a list of the reasons a child can get points and the amount they will receive can be found. The scale for days in a row logged in and completed tasks (include counting carbohydrates, injecting insulin and measuring the glucose level) for x amount of days, will continue with steps of 10 for the days and steps 10 for the points. In table 20 a list of what the points can be used for can be found. The design for this system will be made in the prototype chapter. To get the children to try to get more points, some accessories will cost more points than others to keep them motivated. The tasks include the activity of filling in the amount of carbohydrates they eat and then calculating how many units of insulin they need to inject and filling this into the app.

Reason for point	**Amount of points**
First time log in	5
5 days in a row log in	20
10 days in a row log in	40
Completed all the tasks for 1 day	10
Completed all the tasks for 5 days	30
Completed all the tasks for 10 days	50
Points from parents	Depends on the choice of the parents

Table 22 - Ways to earn points

Usage for points		**Amount of points**
Hats	Beanie	5
	Baseball cap	10
	Cowboy	20
	Unicorn horn	30
Collar	Normal	5
	With spikes	10

	With glitter	20
	With a bell	30
New background	Jungle theme	10
	Princess theme	20
	Knight theme	30
	Pirate theme	35
Wall decoration	Fairy lights	5
	Painting	10
	Glowing stars	20

Table 23 - Ways to spend points

Schedule

One of the most important parts of this app is creating and using a schedule. When the parents fill in the information, and the child logs in into their account, the schedule and all the other information will be uploaded into the child's app. At the beginning of a time slot a push notification will be send to the child's phone/iPad. If the child ignores the push notification, a new one will be sent after 15 minutes until the child responds to the notification.

When the child clicks on the notification, they will enter the app. A popup screen will appear where the child needs to fill in how much carbohydrates they are going to eat and then calculate how much insulin they need. When the calculation is correct, a new message will be shown that congratulates them and tells them they can eat when they insert the amount into their needle or pump. If the child uses the bolus-wizard setting on their pump, they will still get the same assignment. The only difference is that they will get a different end message when the job is completed. If the calculation is not correct, the screen will show a try again message.

The push notification just before bed, will be different. Since they do not eat the but need to go to sleep. The message will ask them to insert their blood-sugar level and will give them some advice when it is too high or too low.

Feedback

There are two different types of feedback messages that will show in the app. The first are the reward messages and the second are the need messages. There will also be specific messages regarding the DMT1 elements. These will be evaluated in the chapter 6.

The goal of the pop ups is to be motivating, entertaining and to generate some type of feedback. There are different interactions that require pop ups. Below is a table containing the subgroups of pop ups and some examples that can be used when a functional game will be made. The examples are in Dutch, since the game will be made for Dutch children.

Goal	Example
Positive feedback to completion of a task	Goed gedaan! Je kan *bijnaam avatar* nu eten geven.
Constructive feedback to failed task	Jammer. De opdracht is niet goed gegaan. Probeer het nog een keer!
Rewards for repeatedly doing a good job	Je hebt vandaag alle taken goed gedaan. Hiervoor krijg je 10 punten om nieuwe spullen te kopen!
Message when the avatar needs something (food, water etc.)	*bijnaam avatar* heeft geen water meer! Geef hem snel nieuw water.

Table 24 - Example of pop up messages

One of the adults commented that their child uses a pump and that the app may be less useful for them. They also hope that the app would not take too much mental energy to use.

Game elements

To be able to make the game work properly, there are certain functions that need to be used in the game. Most have something to do with keeping the animal healthy and alive. There will be other game elements more focused on the DMT1 educational part. The elements that should be included are feeding, playing, cleaning (washing), sleeping (will do this automatically when the bar gets to low), give water, peeing and buying accessories. In the table below the ways to show these elements is shown. In the prototype chapter designs for these elements will be made.

Game elements	Design
Feed	Bowl, different snack per animal (Bunny: carrot. Dog: bone. Cat: fish. Monkey: banana)
Play	Ball (Could investigate specific toys for the animals)
Clean	Brush
Sleep	Animal bed
Water	Bowl
Buy menu	Grouped per category

Table 25 - Game elements that should be included

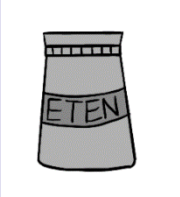
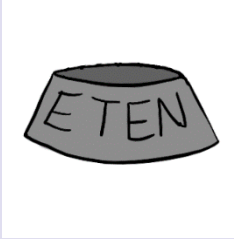
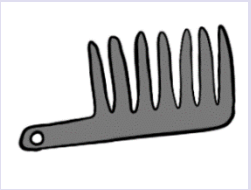
5.2.1.2 Prototype

During this version of the prototype the focus is on the design and implementing the functions a semi working prototype that can be tested. The colors and overall interface design will be the same as the parent's app to create some cohesion. The children will be asked about their opinion of the color scheme so we can see what both focus groups prefer.

For this prototype, standard designs will be made for the look of the game. This includes the first background, the overall interface design, and the way the pop-up messages will look. The sketches for this can be found in Appendix XIII.

The dinosaur avatar will be replaced by a monkey. These sketches can be found in Appendix XIII.

Next the multiple smaller objects need to be designed. Such as the food icon, the water icon etc. this also includes the accessories that can be bought. In table 26 the designs can be seen according to the category they are in. these can be easily implemented into the game. The game is in Dutch, since this is the main language of the users. Some of the game elements will therefor suggest or use Dutch.

Game element	Icon	Full	Empty
Feed			
Play			
Clean			
Sleep (will do this on its own when the bar is too low)			

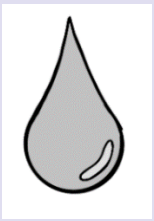
Water	  
Buy menu	

Table 26 - Game element symbols

The feedback is also important. To show the feedback, talk bubbles will be used. This way it looks like the animal is talking to the child. For showing if they are hungry or want to play, a thought bubble will appear with the icon inside that the need corresponds to. This way it should be easier for the children to see what they need to do when one of these bubbles appears. The design for the speech bubbles will match with the interface design and the colors.

Some sketches for the rewards will be made so they can be evaluated. In this prototype they will stay as sketches, so it is easier to change something when we look at the feedback. The sketches can be found in table 27.

Accessories	Icon
Cowboy **Beanie** **Baseball cap** **Unicorn horn**	
Normal **With spikes** **With glitter** **With a bell**	

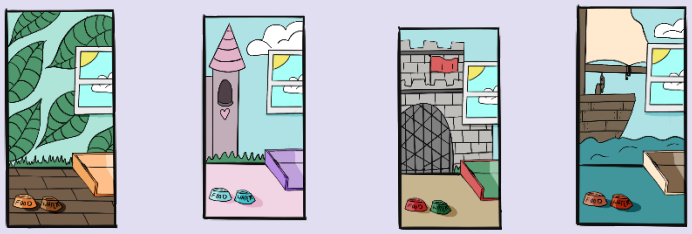
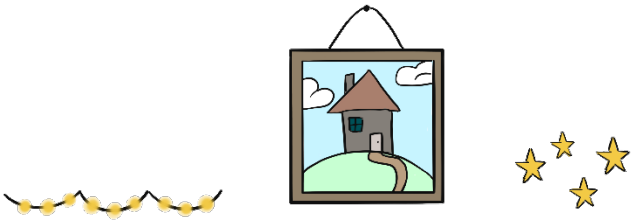
Jungle theme **Princess theme** **Knight theme** **Pirate theme**	
Fairy lights **Painting** **Glowing stars**	

Table 27 - Accessories Icons

The schedule will present itself in two ways. The first one is that the app will send messages via the notification system in the phone. The child will get a message that will remind them to use the app and do their related DMT1 tasks. More specifics on this will be researched during chapter 6. They will also receive notifications when the animal is hungry or thirsty.

When the child is already playing the game, the messages will look like speech bubbles. They will look the same as the feedback messages. The DMT1 specific functions, such as the steps they need to take before they can eat and the feedback for this will be looked at during chapter 6.

5.2.1.3 Evaluation

This evaluation will focus on the different options for the final design. Such as color, font, style of graph etc. that have been made using the feedback from the previous chapter. The interactive prototype will be tested to see of the interface is easy to use and understand for the children. They will need help with the evaluation from either a teacher or their parents. The parents of all the children have given their consent into letting their children participate.

The questions can be found in Appendix X. These questions were categorized using the UTAUT model. Some extra questions were used to get feedback on the design.

Due to unforeseen circumstances, it was not possible to evaluate in person. Therefore, a google form has been made to still get the feedback that is needed.

Participants

The participants have been recruited via Diabeter. This is a specialized Diabetes facility with a focus on children. In table 25 the information from the participants can be found. They are all in the focus group. Since

the focus of this evaluation is to see what types of functions are necessary for the next and final version of the game, it does not matter that the participants have DMT1.

ID	Gender	Age	Earlier participation
C5	Woman	9	No
C6	Woman	12	No
C7	Woman	6	No
C8	Woman	8	No

Table 28 - Personal information participants evaluation children 2

Feedback

To keep the information from the evaluation easy to follow, this chapter has been divided into chapters which relate to the types of questions that have been asked.

Performance expectancy

The results for the performance expectancy have one outlier. 3 out of the 4 participants have agreed that the reminders would help them with using the app more often, they also agreed that the rewards would contribute to this. They were quite neutral about the fact that the reminders would help them not forget to measure their blood sugar levels. However, everybody had a different answer to the statement “I will forget to inject my insulin less if I use this app”.

The outlier was participant C8. They answered strongly disagree to all these questions. This may have something to do with their comment at the end. They did not understand the prototype. I, unfortunately, do not know why because the evaluation was done with google forms and it is very difficult to ask to follow up questions.

Effort expectancy

3 out of 4 of the participants agreed with the statement that the app was easy to use. Except for one, they stated this as well in the comment section in the end. They did however think that it is easy to learn how to use the app. 3 out of the 4 agreed that they would recommend the game to their friends with DMT1, unfortunately one of the participants disagreed with this statement.

Social influence

2 out of the 4 participants would agree with that the statement that they would show this to their friends. 1 was neutral about this, and the last one would not show the app to their friends. That is unfortunate and should be looked at if more evaluations would be done.

Behavioral intention

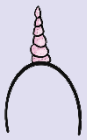
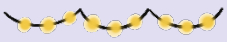
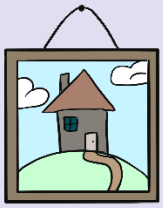
Fortunately, all the participants agreed with the statement that they would enjoy playing this game. They also agreed that the game would be interesting to use. This means that there is no reason for any changes to the basic game itself.

Use behavior

The amount of time the participants would use the app differs per person. This is understandable, since not everyone uses their phone all their phone all the time. The average answer to the statement would be that they would use the app at least once a day. Which is the minimum we strive for. For the statements “I would react to notifications”, the average answer was agreeing. Which is also good. Since this is a big part of getting the children to work with a schedule.

Design

When we look at the design questions, they overall agreed with each other. Which is not necessarily positive or negative. They only show what is the most favorable design. This could benefit us by making the most favorable options the most expensive. To make an easy overview of these choices, the favorable choices were put into a table. Which can be found below.

Question	**1st choice**	**2nd choice**
Hat		
Collar		
Wall accessory		

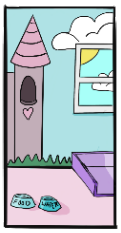
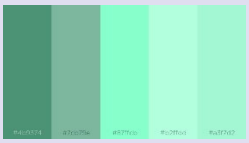
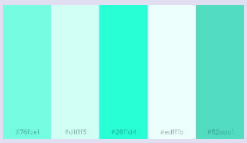
Background (this was a tie)		
Color scheme		

Table 29 - Results design evaluation child 2

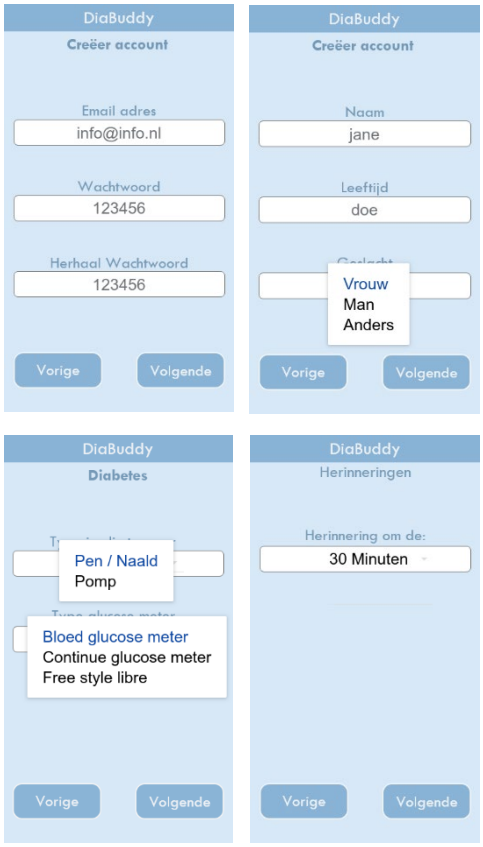
The results of the design part of the evaluation may be biased, since all the participants are women. The generally favor pink and sparkles. From the evaluation it was also clear that the participants want to do the standard activities with their character. Playing was the most frequently mentioned. There was one answer for the optional section that asked if the child must read everything themselves or if the animal talks. This is a very smart question since some of the younger children may not be very good at reading. Giving the options to turn talking on and off should be considered.

6 Realization

The goal of the specification phase was to get more insight into what kind of functions were needed to create a useful and functioning prototype. The feedback gathered from that phase will be used during this chapter. A final prototype for the parent version and for the child version will be made. From this prototype and all the information gathered in earlier chapters, a final list of requirements will be made. This list will help in further research into this topic and will help with creating a working version that could be published.

6.1 Final Parent version

To make this prototype as functional as possible, another program was used to add certain functionality.



According to the feedback from Chapter 5, the functions, and the current prototype work well. So, there was little to edit in this prototype. One functionality was added though, the parents can now choose the interval between which the reminders will be send to the child's phone. This function was added to make the app even more personal. In figure 19 you can see some of the designed screens. In Appendix X the full design of the final prototype for the parents can be found. This is ultimately the same as the 3rd iteration. In Appendix XIV the final version where proto.io is used for functionality can be found. There are not a lot of differences in the design between these. The biggest difference is the functionality of the prototype itself.

There were some functionalities that could not be added. Either due to the use of the programs or the time constraint.

- Saving of input data.
- Responsive graphs.
- Connection between the parent and child versions.

6.2 Final child version

To make this prototype as functional as possible, another program has been used to add certain functionalities to the already existing prototype. Such as being able to choose between the different avatars and changing the rewards according to the results of evaluation 2. In the table below the new version of the rewards that can be bought with certain amount of points can be found. The changes that have been made according to the ranking found in the evaluation from the last prototype, will be marked in red.

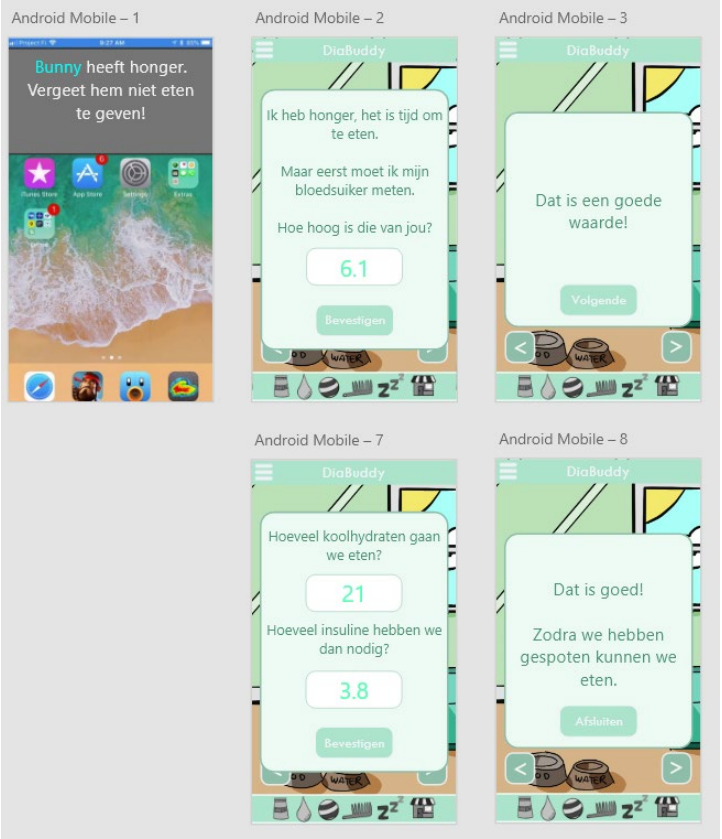
Usage for points	**Old**	**New**	**Amount of points**
Hats	Beanie	Beanie	5
	Baseball cap	Baseball cap	10
	Cowboy	Cowboy	20
	Unicorn horn	Unicorn horn	30
Collar	Normal	With spikes	5
	With spikes	With a bell	10
	With glitter	Normal	20
	With a bell	With glitter	30
New background	Jungle theme	Knight theme	10
	Princess theme	Pirate theme	20
	Knight theme	Princess theme	30
	Pirate theme	Jungle theme	35
Wall decoration	Fairy lights	Glowing stars	5
	Painting	Painting	10
	Glowing stars	Fairy lights	20

Table 30 - Reviewed rewards child

It will also add the specific tasks to be completed related to DMT1. One of the key parts of this game is the personal tasks the children must do before they eat and go to sleep. In figure 20 some examples of these tasks can be found. The full design can be found in Appendix XV. These tasks have been implemented into the final version. But since the data the parents put in will not be saved, the tasks are an example of how they will look like and this part of the prototype is therefore not functional. To make the app more personal the child will be able to choose how much they want the parents directly involved. There will be 3 options.

1. I need the help of my parents often.
2. I sometimes need the help of my parents.
3. I do not need the help of my parents.

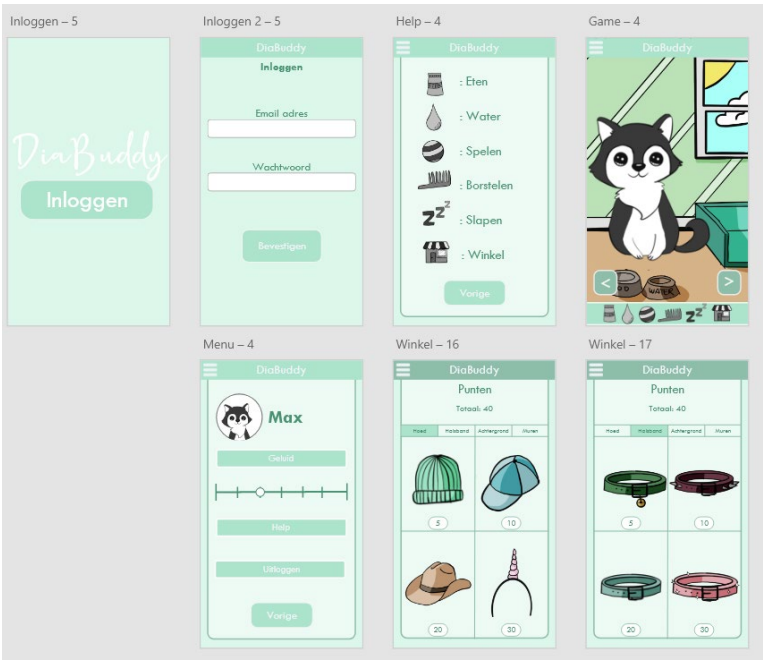
This will change some of the dialog during the tasks the need to complete.



In figure 21 final design can be found with some examples of different screens. In Appendix XVI the full application can be found including a version which shows the flow between the screens.

Some things that could not be included into the final version but were mentioned and should be added to a next prototype:

- Saving of input data.
- Connection between the parent and child versions.
- Responsive DMT1 tasks.



7&8

Final Phase

Chapter 7 – Discussion & Future works

The goal of this research was to help children with DMT1, and their parents have more control over the disease and to teach the children more about their disease in a motivating, useful and fun way. To achieve this the following research question was used: ***What are the requirements for a functional and educational serious game for children with DMT1?*** Creating structure in the lives of the children and their parents was found to be the most important part of getting control over the DMT1. That is why the focus was put on this goal during the research. During the research it was also found that using a reward system were the parents could give the children points and the children could use the points would be very beneficial to both their motivation to use the app. Making both the apps personal to the user also benefits to the motivation of the user, but most important to the usefulness of the app.

When we look at the literature research done in chapter two, the biggest problem facing the children, parents and diabetes specialists is controlling DMT1. Since DMT1 is a chronic disease, it is important for that the child and parents know how they can take control of the disease to minimize the negative effect later in life. Therefore, the early education is very important. Not only for the child but the parents also need to be educated. The analysis of the literature research also showed that having a structured lifestyle, especially in the first stages of diagnoses, can be very beneficial for children with DMT1.

From the interviews with the diabetes specialists it became clear that one of the hardest things for the parents to do is to let go. At some point the child needs to learn how to deal with the disease. If the parent is too overbearing and does not let the child handle their own problems, the child will expect this for the rest of their lives. The mental health of the parents has a big impact on the children. Their anxiety regarding life and the DMT1 of their children influences their children.

Therefore, creating an app that can create structure and control in both the lives of the children and parents was a priority in this research. Doing this by creating an app for the parents that gives them insights into their child's behavior may take some of their stress and anxiety away. This was further confirmed by the interviews done with the Diabetes specialists.

The evaluation from the first iteration concluded that creating a personalized scheduled with reminders for the children would help them. The functions that should be added to the app would be for the parents to be able to see how many times the child reacts to a reminder, how much they use the app in general and that they would be able to send rewards to their child at certain points. The reminders would help the children in sticking to an eating schedule. In the earlier stages of dealing with DMT1 this is very important. Since forgetting to use insulin can be very dangerous for a patient.

Just as the parent's version, an important part for the child version to keep them motivated is to add the rewards option. The child will want more points to buy certain things. This will help them to keep being engaged with the app. The types of rewards they can earn is also important. They can earn points by

completing certain tasks. The points can then be spent on rewards. The most wanted rewards should cost the most points to motivate the children even further.

To be able to create a useful and educational game for the children there are certain aspects and functions that should be included in the app. Since the goal of the game is to teach the children how to deal with their DMT1 using a structured narrative will have the most benefit. This will make sure that the information that the child learns is what we want them to learn. Using constructive feedback is also very important. This is important, since it will help the child be motivated and it will let them know if they are doing well or not. The way the app is designed is also important. The interactions should be logical and easy to use and learn to use.

To further ensure that the children learn something from the app that they can use in real life, the app needed to be personal. That is why the parents could fill in the child's schedule, type of insulin injector and measuring device. This helped in creating personalized DMT1 tasks.

A strong point from this research was that this specific idea of combing a child's game with a visualization version for the parents did not exist yet. This research combined a lot of existing research that may not seem to have any benefit to each other into something that hopefully has a very positive effect on the DMT1 community. Since a lot of background research was done for the list of requirements, it may serve as a good basis for further and more specific research into this subject.

One of the biggest obstacles for this research was the unfortunate rise of COVID-19. This had a big impact on the way the tests were held. Ideally the evaluations would be held face to face to see the way the participants react to the prototype and questions. The best way to get more specific answers and more details to use for feedback would be to be able to ask follow up questions. For future research it would be strongly advised to set up the evaluations in this fashion.

There was also a big impact on the time it took to complete the evaluations. Since everything had to be done online a lot of time was spend waiting for answers. The future evaluations should be worked out in more detail and done in person to make sure that all the information that is need can be extracted well.

The general idea for the game was not researched beforehand. It should be noted that it is not clear if this is the best way for this game to work. But the evaluations did show that the idea was well received.

There were some functions that could be researched in future work that were mentioned by participants. Such as adding an audio option for the children. This option would read the text out loud so that children that cannot read well will still be able to use the app as it is intended. Another option could be to add a community. Letting the children connect to each other can help with motivation. This should be further researched. Adding more options to personalize the app for the parents and the children could be beneficial and should be investigated in future research.

Since there are no other apps that function the same as this one, it would be strongly advised to make this app a working, programmed and functional prototype and have this tested with a large group of participants.

Chapter 8 – Conclusion

To conclude this research, a new and final list of requirements will be made. The base for this list will be the list of requirements made in chapter 4.3, ideation. This will be done by using the research and sub research questions stated in chapter 1. To create a final list of requirements, multiple processes and frameworks have been used to answer the following research question: ***What are the requirements for a functional and educational serious game for children with DMT1?***

It was clear that creating an app that can create structure and control in both the lives of the children and parents was a priority in this research. Doing this by creating an app for the parents that gives them insights into their child's behavior may take some of their stress and anxiety away.

To motivate the children more, a reward system was added. This way they would be more motivated to complete certain tasks. The parents could also send the children reward points, this helped to motivate the parents and make them more involved with the educational process.

Personalizing the app was also very important. This helped in giving the children the right DMT1 tasks. They relate to them in real life. What they do in the app, they also need to themselves when they eat or go to sleep.

These observations have been used to generate a final list of MoSCoW requirements. These can be found in table 31 below.

Final MoSCoW requirements

Ranking	*ID*	*Requirement*	*Source*
M	I1 & D6	Create structure in their life	Interview with diabetes specialists, DMT1 research, all the evaluations for the parent's version
M	I2	Consistent reminders	Interview with diabetes specialists
M	-	Different options for the children to spend their rewards points on.	1st iteration child
M	I3	Create version of the game specifically for the parents. The app will focus on analyzing the child's behavior in the game.	Interview with diabetes specialists
M	D3 D2 D1	Specifically tailored to patients - Give option to choose which type of glucose monitor is used. - Give option to choose the way insulin is injected	DMT1 research
M	I6	Reward system that the parents can use.	Interview with diabetes specialists

M	S3 & I4	Use constructive feedback for both the parent's app and the child's game.	Serious games research, Interview with diabetes specialists
M	-	Data should be properly secured.	3rd iteration parent's
M	S1	Use passive game elements	Serious games research
M	S6	Use well designed interactions. The interactions with the app and the results from an interaction need to feel logical. (such as: when a press the button that says 'BACK' the app reacts with switching to the last used screen).	Serious games research
S	-	Clear graphs with option to change axis details or data range for the parent's version.	2nd iteration parent's
S	-	More graphs for specific DMT1 tasks.	3rd iteration parent's

Table 31 - Table 31 - Final MoSCoW requirements. M = Must have, S = should have. D = DMT1 research source, S = Serious game research source, I = Interview diabetes specialists' source.

References & Appendices

References

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Appendix I

Interview questions – Doctor

Date:

General

Explain research, focus group = between 6 and 12.

1. Name and Job description (work experience)

Diabetes

2. **What do you think are the biggest obstacles with teaching children about DMT1?**

3. What are the learning goals for the education program? (leerdoelen)

4. **What are things that the regular educational program is missing?**

5. In what way do you think that parents influence the education of children with DMT1?

Games

Explain game idea: avatar + parent/doctor integration

6. What do you think about the avatar idea?

7. **Which functions should the avatar reflect?**

8. Most games use Challenge, Feedback and Graphics, what do you think should be the focus point?

9. **Passive and active games. Which do you think would work the best?**

10. **If we would implement parent/doctor control, do you think this would motivate the children?**

11. What would be preferred functions?

Appendix II

Transcribed Interviews

What Jaimy says is *cursive.*

What the interviewee says is normal.

Diabetes specialist 1

Function is pediatrician started working in April 2004

If you ask what the biggest obstacles are, that depends on the age of course. Before they are 6, the parents often handle the treatment. Around 6 and 7, they start to measure their own blood-sugar level and helping, this is also something we try to focus on, but some children are not ready for this yet. Also, some parents are not ready for this. That is even more difficult, because the treatment is already going smoothly, so you forget to let them do it themselves. Taking their own responsibility is a big problem for children between 6 and 8. This is also a problem when they go to secondary school. Basically, the whole age group between 6 and 12.

When they just start with secondary school, there is so much new information, that they do not have the time for their Diabetes anymore. But there are a lot of barriers of course. Like, are you smart enough, do you get enough time for this or is it very busy at home? Is there a good schedule, that kind of thing.

It also depends on the person of course and what the problems are.

What are the, or better said if you get have diabetes at one point the parents do less, and the child will do more. What are the big things you focus on? What you teach them, do you do that in smaller steps or teach them all at once?

Uh no, we start with measuring the blood-sugar and having them give themselves their insulin. Afterwards it is more about carbohydrate counting of that fits in the treatment. It will become more difficult during the process. And what is very important, what we try in the beginning, is looking at the structure. Like, hey you are going to eat so you need insulin. The realization that you need insulin as base for your food, that is a focus point. Inject insulin first, then eat. That is something you might recognize.

Haha yes, I had the same problem.

So first measure your blood-sugar, then inject insulin and then eat. If you get a bonus if you measure and inject insulin before you eat and think about it and do something, then it would be great.

Yeah, sometimes it takes some effort. It is something that happened to me as well.

Do you think something is missing in the educational program? In a general sense.

There are a lot of things that can be perfected. You learn the transition from parent to child, an important part is the communication from the parents. Parents often think that the child will do their things, but it is

important that they know where to go for help and not let the child do everything themselves. That is also a problem. That is a focus point, to discuss with the parents that it is not only the tasks but also the timing of the injections and the communication. That is something that goes well in the earlier stages, but it will deteriorate when they get older. But that is why we want to make sure these things are handled well, so there are no problems in the future.

Then I do not have to ask this question, how the parents influence the child's diabetes. Since you already talked about this.

Then more specifically about the game idea we have now. The idea now is that it will some sort of Tamagotchi, it will help you remember that you need to inject insulin, but you can also play minigames to learn more about carbohydrate counting. There are already some games that focus on this, but I want to focus on is that it will be more personal. And that the parents and the diabetes specialist have access to what the child needs to learn more about. And that you can even fill in your own schedule so the app can remind you to measure your blood-sugar. That they not only need to take care of themselves but also something else that has the disease. What do you think about this?

Interesting! The first time Gerrie told me about your project, I was like oh that already exist. But how you explain it to me know, then it does not exist yet. Taking over the parent role, is what happens basically. It is very interesting. There already is a game called Grip, where you must complete a parkour on time and keep your blood-sugar level balanced. That already exist for a long time. I wonder if it is entertaining for boys and girls?

The idea is that you can choose your own avatar. So, you would have some that boys like and some that girls would like or both.

Do you also make one for injections or pumps?

I have thought about it. But since I do not have a lot of time, I would have to focus on 1 of the 2. But I am not sure which one would be better. What do you think?

Oh, that is very difficult. In the beginning they use injections, so that could be appealing, but the younger they are, the earlier they will use the pump.

You could also do make a transition when the child will start using a pump instead of injections. That is something I must think about.

Yes, since these two have different things that you will need to teach. There are some specific things that happen in this transition, the responsibility also changes.

A very quick last questions, do you think that the parent and diabetes specialist version of the app need a lot of control or not? So, do they have a passive or active role?

I would like to have influence on the child's app, but I already know that a lot of people will not use this, I think. For the parents I am not sure. I would let parents use it more the diabetes specialists.

Diabetes specialist 2

26/11/2019

Function Diabetes specialist since 2016.

Project Introduction

What do you think are some of the obstacles for children to deal with Diabetes?

I think that they their concentration and focus is easily pulled to something more interesting for them. They are not always open to talk about their disease, they do not feel like doing something with it.

A little motivation.

Well motivation, the disease is already no fun, they have better things to do. That they must come to us when they could be playing with their friends. That are some of the things involved.

And what do you think are some of the harder things for them to learn?

That is a good question. Carbohydrate counting is mostly done by the dietitian. The injections and measuring the blood-sugar is something we do when they are new. That goes well most of the time. If they are in the transition phase, then the children can get scared to do things themselves or the parents have done it for a long time so they may think why change this easy way for me? They are scared to do things themselves and how do they need to do this. Or sometimes the parents just want to fix all the problems. That is something you also see.

In the end the children must do it themselves, the parents must let go.

Yes.

Do you think there is something missing in the way the Diabetes education is working now? 3.30

Well, nowadays there is already a lot with technology and apps. I think we are already working with instructional videos. So, I think, that is a good thing since they can easily watch how the need to use their sensor. There are already some videos for this, so we send them these videos to learn from. Uhm, well. So maybe focus on the younger children and incorporate games/playing in it. That something we do not really have yet.

Oh right, those videos are nice to use. Especially with the sensor.

Most of the time, it is easier to see then to have it on paper.

How do you think parents have influence on the diabetes educational process?

They have a very big influence. Positive as well as negative. If you support a child well then that will help the child in the positive sense. If you say, go fix it yourself, then they will be influenced in a negative way. You also see that some parents still want to do and fix everything for the child. It is hard for some to let the child

handle things. This way the child does not understand the disease that well. And when this is already happening, it can be difficult to break the cycle.

Some parents have a hard time letting go.

Not all the parents, but it is something we notice.

Then some more about the game itself. (Explanation is the same as with Per Winterdijks interview).

I think it could be fun. It is interesting to see if they must take care of something/someone else, would that work better? Or worse? They only thing you must be careful with is that they need to take care of the avatar but also themselves. So that they do not forget to take care of themselves. Maybe say that they first must do their own thing and then let them take care of the avatar. Something we notice, is that when they get a test pump, which does not use insulin but a salt solution, we have to say: do not forget to inject your insulin. Use the pump afterwards and do not forget that the pump uses tests settings, pay attention that they do not get to confused about these settings.

Then it will probably be that the avatar first tells them that they need to measure the blood-sugar and inject the insulin and the do it with the avatar.

What do you think are some of the things the avatar needs to represent?

I would focus on the feeling if that is possible. So, the learn that when they do not feel well that they measure their blood sugar. It can be hard for children to notice they do not feel well and then notice if it is because their sugar is low or high. I am not sure if you can do that, but it would be nice to implement.

Do you think if a control function for the parent or doctor is implemented, that that would motivate or unmotivated the children?

Depends on how you would do this. It could be motivating when you can praise them, but when you say "hey, you're not doing well" then it can turn around. So, it depends on the communication.

More like giving them feedback.

Yeah, if you keep it positive and open, then I do not think that there will be negative effects.

So, keep the feedback positive, and do not complain.

Yes, because that is how it works in real life as well. Saying "well your high again and you do nothing about it." We know that that does not work it is not motivating at all.

You could also implement some smaller minigames. Do you think this would be beneficial or just focus on taking care of the avatar?

That depends. On the one side, if it shows that it could work then sure. But I think it should not be too much, otherwise there is too much to focus on.

Diabetes specialist 3

26/11/2019

Function is Diabetes specialist since July 2019 at Diabeter. Has been a nurse before that for 6 years.

Project introduction

What do you think are some of the obstacles/problems when teaching children about Diabetes?

It is a lot of information at once, so they can lose their focus fast. Children at 6 have are still learning to count. So, carbohydrate counting can be difficult for them. And this results in the parents taking over. But if you talk about a child of 6, then the parents are still doing a lot when it comes to taking care of the child's Diabetes. They can insert the amount of carbohydrates themselves, but the parents still count them. When you are starting to look at 10 years old, the basis will be made between 6 and 10 years old, so their obstacles…

Like what do they find difficult in general.

In that sense, that target group still listens to their parents and do what they say. But during puberty this will become more difficult. I am thinking about what I have experienced while working here. Forgetting is a big problem. You must do a lot of things. It also depends on at which age they are diagnosed. If they are around 9 you can start by teaching them all the basics. But when they are still 6, then those basics will be taught to the parents.

What do you think is missing in the educational process for children with Diabetes?

The review moments are very well. But I think everything is working well. We have protocols which state what we need to do, which is working well so far. But to support a child, then it can be simple things. It also differs per person. Because some children have a need for a game or playing. But some children just need the practice. But I think that this is working well now. I cannot think of an improvement right now.

How big do you think the influence of parents on the child is?

Very big. The basis will be made by the parents. If a parent is not coping well with the process, then these feelings and behavior can be transferred to the child. Parents also have a hard time letting go. That the child does not become the "owner" of the disease. When they go into puberty, then letting go is very hard. That is where you see things going wrong.

Then some more about the game itself. (Explanation is the same as with Per Winterdijks interview).

I think it is funny idea, I am thinking about using a Tamagotchi. And then implementing the schedule. So, it would help the children in a fun way to remind the children. But I also think it is difficult for schools since some schools are already apprehensive about the pumps. But I think that feeding the avatar and injecting the avatar will help with remembering to do things. If they have a pump, then they must fill in their information twice which can be a bit much. But if you use it as a reminder, then it might work.

Remembering is a big part, but I am looking into making a version for the pump or injections. I am now leaning to only doing injections.

Oh, I would focus on the pump since they also must focus on snacks. And most children get a pump very fast. With injections you only do it 4 days a week, so it is not necessary to remind them.

I will investigate which of the two I will use.

What do you think should be the focus of the app? What could use some more attention?

I think the reminders are very important. Maybe look at faking carbohydrates. Or doing corrections for high blood sugar. There are children that add extra carbohydrates, so they get more insulin. And they do not realize that it has negative influence on them.

That you implement that if they insert to many carbohydrates for what they eat, then it will tell them what can happen. What is your target group again? 6-10?

No, 6 to 12. If I go older then it will become a whole different target group. In that would be difficult in making games.

Hmm then faking it is not something that happens often.

But you could show an example of what could happen when they inject to much insulin or too little.

Yeah, so the effect of injecting to much or too little. Maybe let the avatar pass out or turn green because it is nauseous.

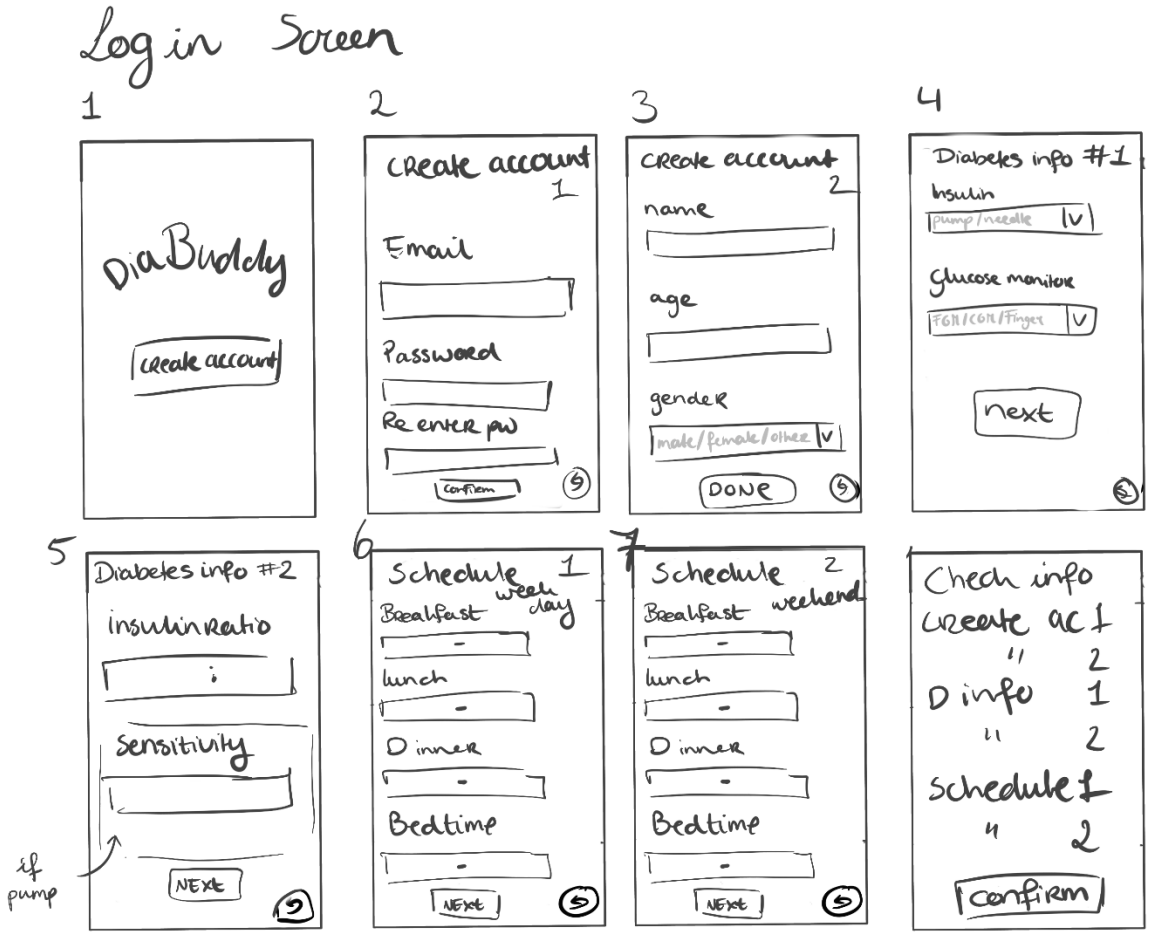
Do you think that if there would be a control point for parents and doctors that it would motivate the children or not?

I think it would not motivate them. I think if they know it, they will not like it. So, keep this more at the background and be careful with what will be shown.

Do you think that they should also be able to do something with the app or just let them observe?

Well it would be good to implement reward system. But that you do not give parents an extra job to do. So, program it in the game itself.

Appendix III




already Screen
loggedin.
1
DiaBuddy
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2
menu
Reminders
game usage
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Game Usage
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Rewards
#1 +10
#2 +2
#3 +7
#4 +5

Appendix IV

Evaluation 1, Parent

What is tested → Integrated functions

Testing format → Informal and participatory

1. Introductions

2. Give them a small background story to inform the user of what they can expect. For now, this includes the general idea of the app and the version for the child. It is important to mention the goal of this evaluation. The information is in Dutch, since the participants native language is Dutch.

Beste deelnemer,

Mijn naam is Jaimy de Kok, ik studeer aan de Universiteit Twente waar ik nu mijn afstudeeropdracht doe.

Voor deze opdracht maak ik een app voor kinderen met Suikerziekte. De app moet helpen met herinneringen sturen wanneer ze eten en hun bloedsuiker moeten checken en insuline gebruiken.

Naast de kinder versie, word er ook een ouder versie gemaakt. Hierbij is het doel dat de ouders meer inzicht krijgen in hoe het kind omgaat met zijn of haar Suikerziekte. Het is belangrijk dat de app persoonlijk overkomt. Dit betekent dat de ouder zelf informatie kan invullen om het kind zo goed mogelijk te helpen.

Dit form heeft een aantal vragen met als doel, meer inzicht krijgen in of de huidige versie van de app de goede kant op gaat. De focus ligt nu vooral op de functies die de app moet hebben.

Alvast bedankt voor het mee werken!

3. Gather personal information:

- Age
- Gender
- Children + their age

4. To get a better understanding of the experience the parents already have with apps. Some more questions will be asked.

- Do you have a Smart phone?
- How many times do you uses your phone per day?
- Do you have any health-related applications on your phone?
    - If yes, Which ones?

5. The following questions will be asked to gather feedback on the functions that should be included into the app.

- Schedule
    - Daily routine
    - Reminders
- Summary
    - Usage of the game
    - Reaction to reminders
- Do you think sending the child reward points would motivate them? Why?

6. Add an optional comment section

7. Thank them for participating

Evaluation 1, Child

What is tested → Integrated functions

Testing format → Informal and participatory

1. Introductions

2. Give them a small background story to inform the user of what they can expect. For now, this includes the general idea of the app. It is important to mention the goal of this evaluation. The information is in Dutch, since the participants native language is Dutch. It is advised to fill in the form together with one of their parents. This will help them if they do not understand some parts of the questions.

Hoi!

Leuk dat je wil meehelpen met mijn onderzoek. Het handigste is als je dit samen met je moeder of vader doet voor als je iets niet snapt.

Voor mijn onderzoek maak ik een spel voor kinderen met suikerziekte. Je verzorgt dan een diertje. Hier wilde ik graag wat vragen over stellen.

3. Gather personal information:

- Age
- Gender

4. To get a better understanding of the experience the parents already have with apps. Some more questions will be asked.

- Do you have a Smart phone or iPad?
- How many times do you uses your phone per day?

5. To see what Children think about games and to get a better understanding of their gaming experience, some questions will be asked about this.

- What kind of games do you play?
- On what platform do you play them?
- What do you think about avatar style games?

6. The following questions will be asked to gather feedback on the functions that should be included into the app and the design of the current avatars?

- Avatar
    - Which of the avatars do you like the best?
    - Why?
    - Is there a type of avatar you would like to see?
- Reward points
    - Would you like to be able to earn points?
    - What would you like to do with the points?

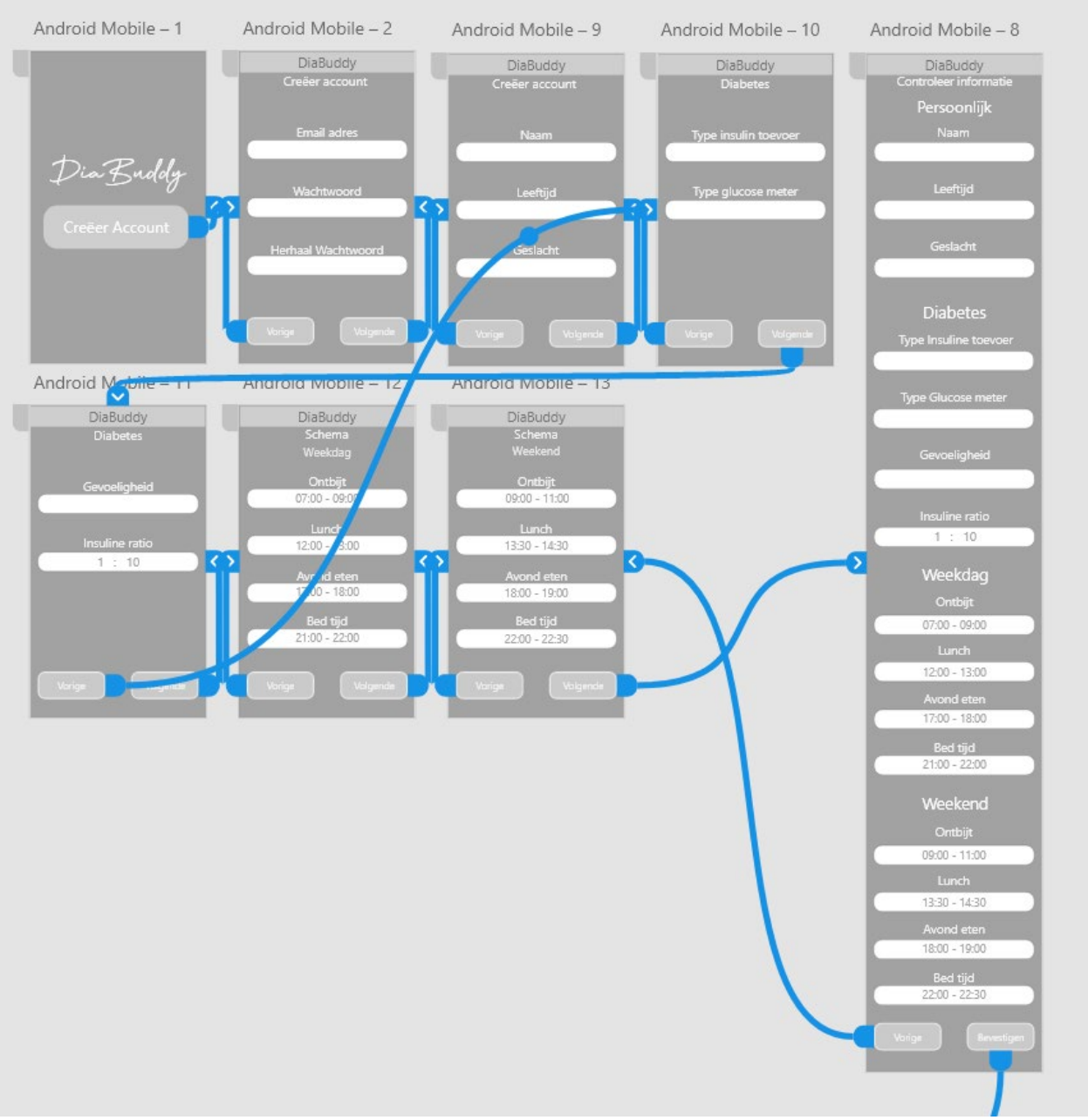
7. Add an optional comment section

8. Thank them for participating

Appendix V


once
1
2
3
4
Dia Buddy
Start
options
log in
email
password
confirm
confirm info
confirm
choose avatar
cat
Dog
Dino
Bunny
12:10
A
menu
Reward
character
quit
sound
pop up
B
mini games
#1
#2
#3
pop up
C
12:10
Reminder
(general message)

Appendix VI


Android Mobile – 1
DiaBuddy
Creëer Account
Android Mobile – 2
DiaBuddy
Creëer account
Email adres
Wachtwoord
Herhaal Wachtwoord
Vorige
Volgende
Android Mobile – 9
DiaBuddy
Creëer account
Naam
Leeftijd
Geslacht
Vorige
Volgende
Android Mobile – 10
DiaBuddy
Diabetes
Type insulin toevoer
Type glucose meter
Vorige
Volgende
Android Mobile – 8
DiaBuddy
Controleer informatie
Persoonlijk
Naam
Leeftijd
Geslacht
Diabetes
Type Insuline toevoer
Type Glucose meter
Gevoeligheid
Insuline ratio
1 : 10
Weekdag
Ontbijt
07:00 - 09:00
Lunch
12:00 - 13:00
Avond eten
17:00 - 18:00
Bed tijd
21:00 - 22:00
Weekend
Ontbijt
09:00 - 11:00
Lunch
13:30 - 14:30
Avond eten
18:00 - 19:00
Bed tijd
22:00 - 22:30
Vorige
Bevestigen
Android Mobile – 11
DiaBuddy
Diabetes
Gevoeligheid
Insuline ratio
1 : 10
Vorige
Android Mobile – 12
DiaBuddy
Schema
Weekdag
Ontbijt
07:00 - 09:00
Lunch
12:00 - 13:00
Avond eten
17:00 - 18:00
Bed tijd
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Vorige
Volgende
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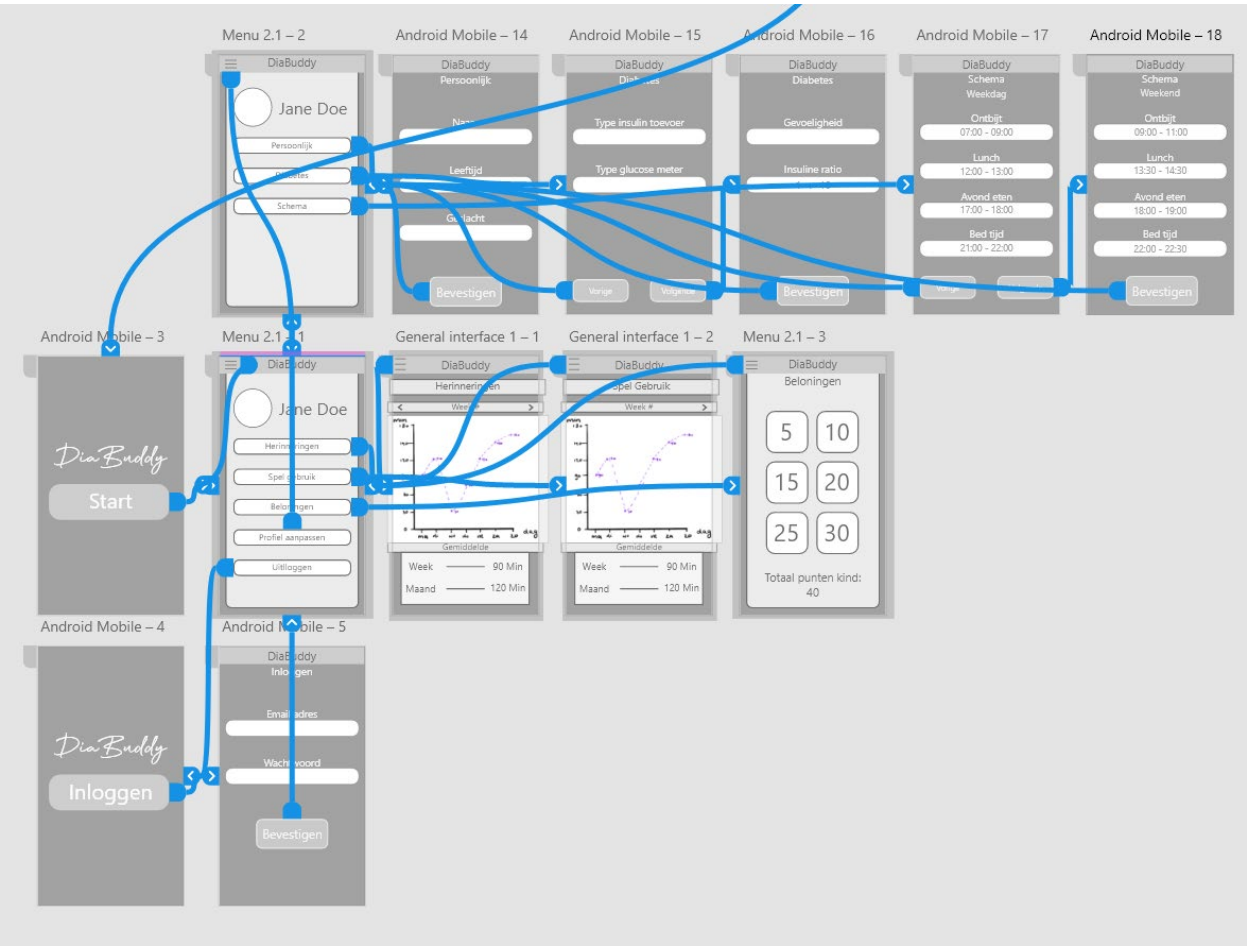
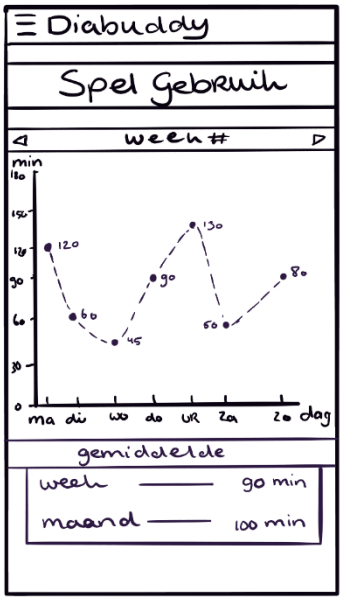
Schema
Weekend
Ontbijt
09:00 - 11:00
Lunch
13:30 - 14:30
Avond eten
18:00 - 19:00
Bed tijd
22:00 - 22:30
Vorige
Volgende


Menu 2.1 – 2
Android Mobile – 14
Android Mobile – 15
Android Mobile – 16
Android Mobile – 17
Android Mobile – 18
DiaBuddy
Jane Doe
Persoonlijk
Diabetes
Schema
Leeftijd
Bevestigen
Type insuline toevoer
Type glucose meter
Gevoeligheid
Insuline ratio
Schema
Weekdag
Ontbijt
07:00 - 09:00
Lunch
12:00 - 13:00
Avond eten
17:00 - 18:00
Bed tijd
21:00 - 22:00
Schema
Weekend
Ontbijt
09:00 - 11:00
Lunch
13:30 - 14:30
Avond eten
18:00 - 19:00
Bed tijd
22:00 - 22:30
Android Mobile – 3
Menu 2.1 – 1
General interface 1 – 1
General interface 1 – 2
Menu 2.1 – 3
DiaBuddy
Start
Jane Doe
Herinneringen
Spel Gebruik
Beloningen
Profiel aanpassen
Uitloggen
Week
90 Min
Maand
120 Min
Gemiddelde
5
10
15
20
25
30
Totaal punten kind:
40
Android Mobile – 4
Android Mobile – 5
DiaBuddy
Inloggen
Bevestigen

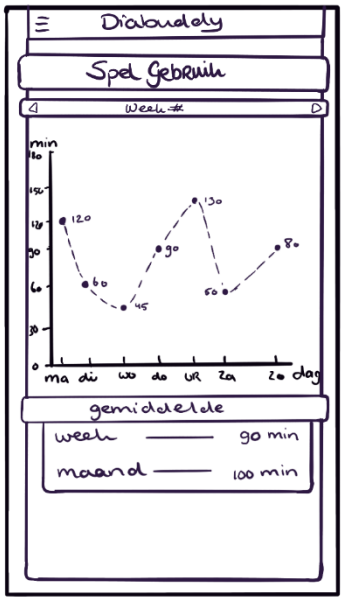
Appendix VII

Version 1



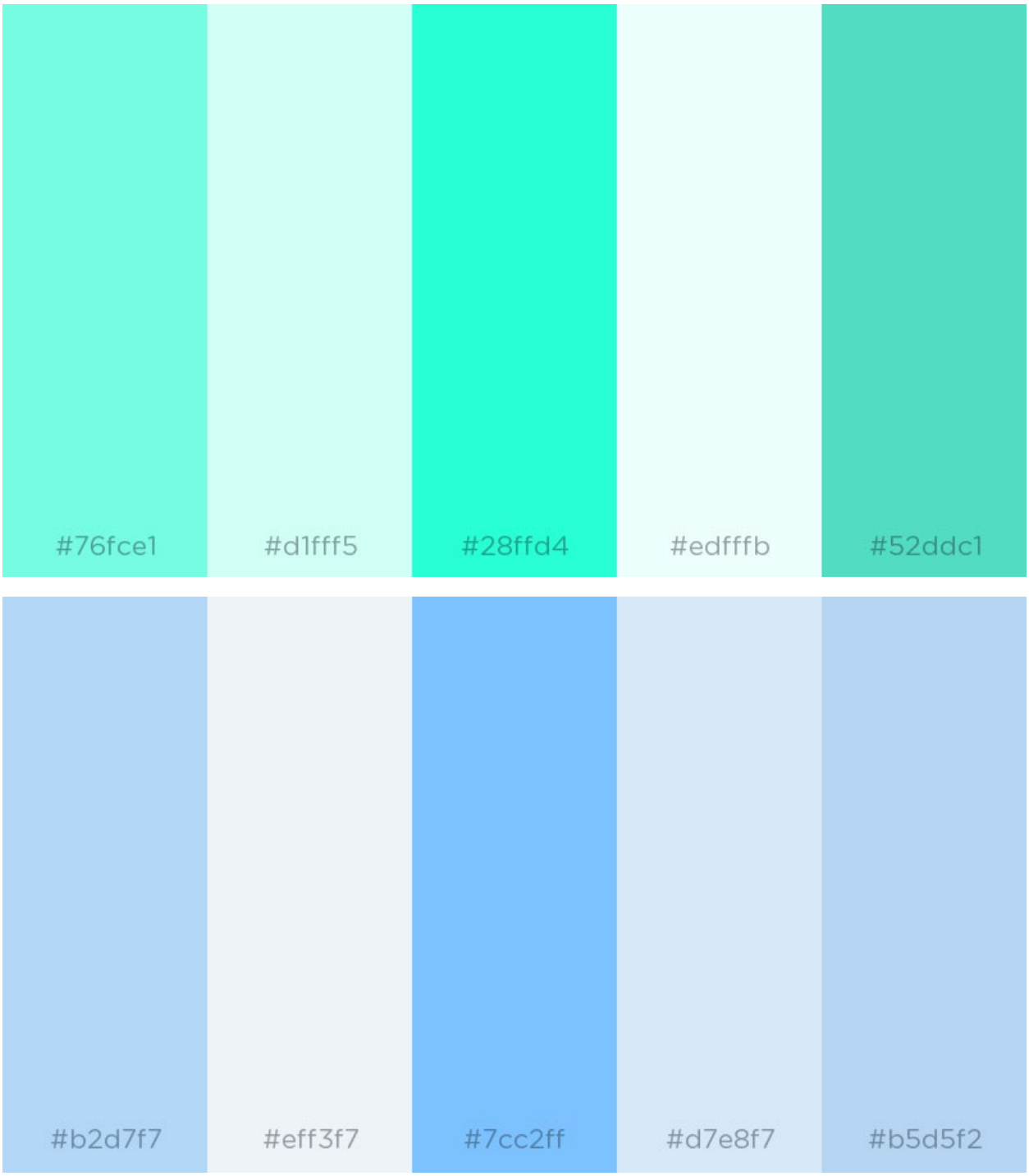
1 B

Version 2



2B

Appendix VIII




#4b9374
#7cb79e
#87ffcb
#b2ffdd
#a3f7d2
#f9fcff
#b5d5f2
#51abff
#4373a0
#0c3963

Appendix IX

Evaluation 2, Parent

Performance expectancy	
De app helpt bij een gestructureerde dag creëren voor mij kind.	1. oneens / 5. eens
De app kan helpen bij het inzicht krijgen in het gedrag van mij kind.	1. oneens / 5. eens
Over het algemeen vind ik deze app nuttig.	1. oneens / 5. eens
De beloningen motiveren mijn kind om gestructureerd de app te gebruiken.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het spuiten van insuline.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het meten van zijn/haar bloedsuiker.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het tellen van koolhydraten.	1. oneens / 5. eens
Effort expectancy	
Ik vind het gebruik van deze app makkelijk te leren.	1. oneens / 5. eens
Ik vind het gebruik van deze app makkelijk.	1. oneens / 5. eens
Ik vind de indeling en gebruik van deze app logisch.	1. oneens / 5. eens
Social influence	
Ik zou deze app aanbevelen.	1. oneens / 5. eens
Ik denk dat mijn gezin het gebruik van deze app een goed idee vindt.	1. oneens / 5. eens
Ik denk dat mijn kind zijn versie van de app zal gebruiken.	1. oneens / 5. eens
Behavioral intention	
Ik zou deze app vaak gebruiken.	1. oneens / 5. eens
Ik vind het doel en gebruiken van deze app een goed idee.	1. oneens / 5. eens
Ik vind het interessant om deze app te gebruiken.	1. oneens / 5. eens
Use behavior	

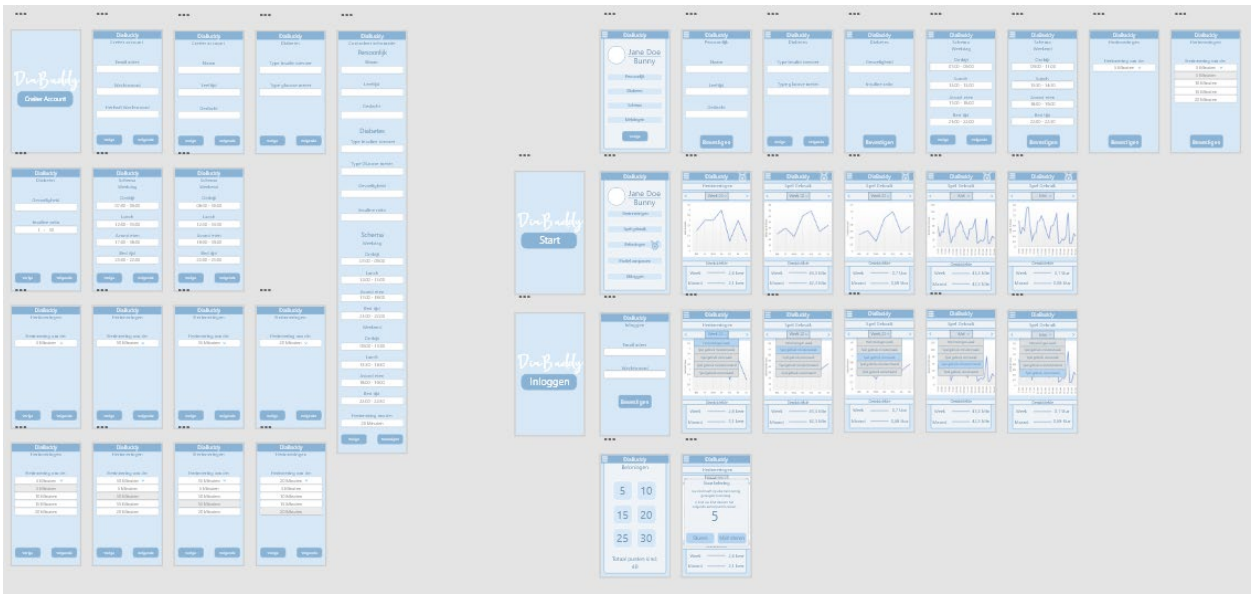
Hoe vaak zou u deze app gebruiken?	1 keer per week / meerdere keren per dag
Ik zou het beloningsysteem gebruiken.	1. oneens / 5. eens
Design	
Welke versie van de algemene interface heeft uw voorkeur?	A of B
Welke versie van de menu interface heeft uw voorkeur? (Specifiek het design van de naam, dierennaam en avatar afbeelding)	A-D
Welke type grafiek heeft uw voorkeur bij de functie spelgebruik? (Hoe vaak gebruikt het kind de app)	Lijn of staaf
Welke type grafiek heeft uw voorkeur bij de functie herinneringen? (Hoe vaak het kind reageert op bepaalde notificaties)	Lijn of staaf
Welk kleurenschema spreekt u het meeste aan?	A-D
Welk font spreekt u het meeste aan?	A-E

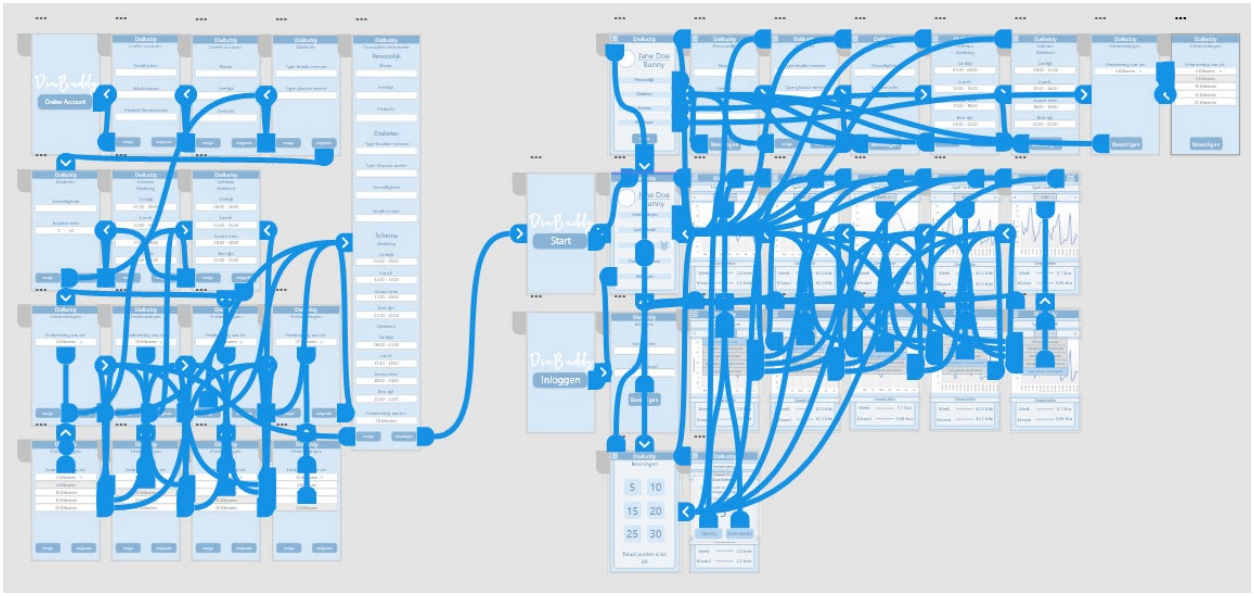
Evaluation 2, Child

Performance expectancy	
De herinneringen zullen mij helpen de app vaker te gebruiken.	1. oneens / 5. eens
De belongingen zullen helpen bij de app vaker te gebruiken.	1. oneens / 5. eens
Ik zal minder snel mijn bloedsuiker vergeten te meten door deze app.	1. oneens / 5. eens
Ik zal minder snel mijn Insuline vergeten te spuiten door deze app.	1. oneens / 5. eens
Effort expectancy	
Ik vond het makkelijk om de app te gebruiken.	1. oneens / 5. eens
Ik denk dat makkelijk is om te leren hoe de app werkt.	1. oneens / 5. eens
Social influence	
Ik zou dit spel aan mijn vrienden laten zien.	1. oneens / 5. eens
Ik zou dit spel aanraden aan andere kinderen met Diabetes.	1. oneens / 5. eens
Behavioral intention	

Ik vind het idee van het spel erg leuk.	1. oneens / 5. eens
Hoe vaak zou je de app gebruiken?	1 keer per week / meerdere keren per dag
Use behavior	
Ik zou reageren op de notificaties.	1. oneens / 5. eens
Design	
Welke van de hoedjes vind je het leukste?	A-D
Welke van de halsbanden vind je het leukste?	A-D
Welke achtergrond vind je het mooiste?	A-D
Welke van de drie zou je op je muur hangen?	A-C
Welke kleuren vind je het mooiste?	A-D
Wat zou je met de avatar willen doen? (Bijvoorbeeld: eten geven, drinken geven, spelen enz.)	Open vraag.

Appendix X


DiaBuddy
Online Account
Start
Inloggen


DiaBuddy
Online Account
Start
Inloggen

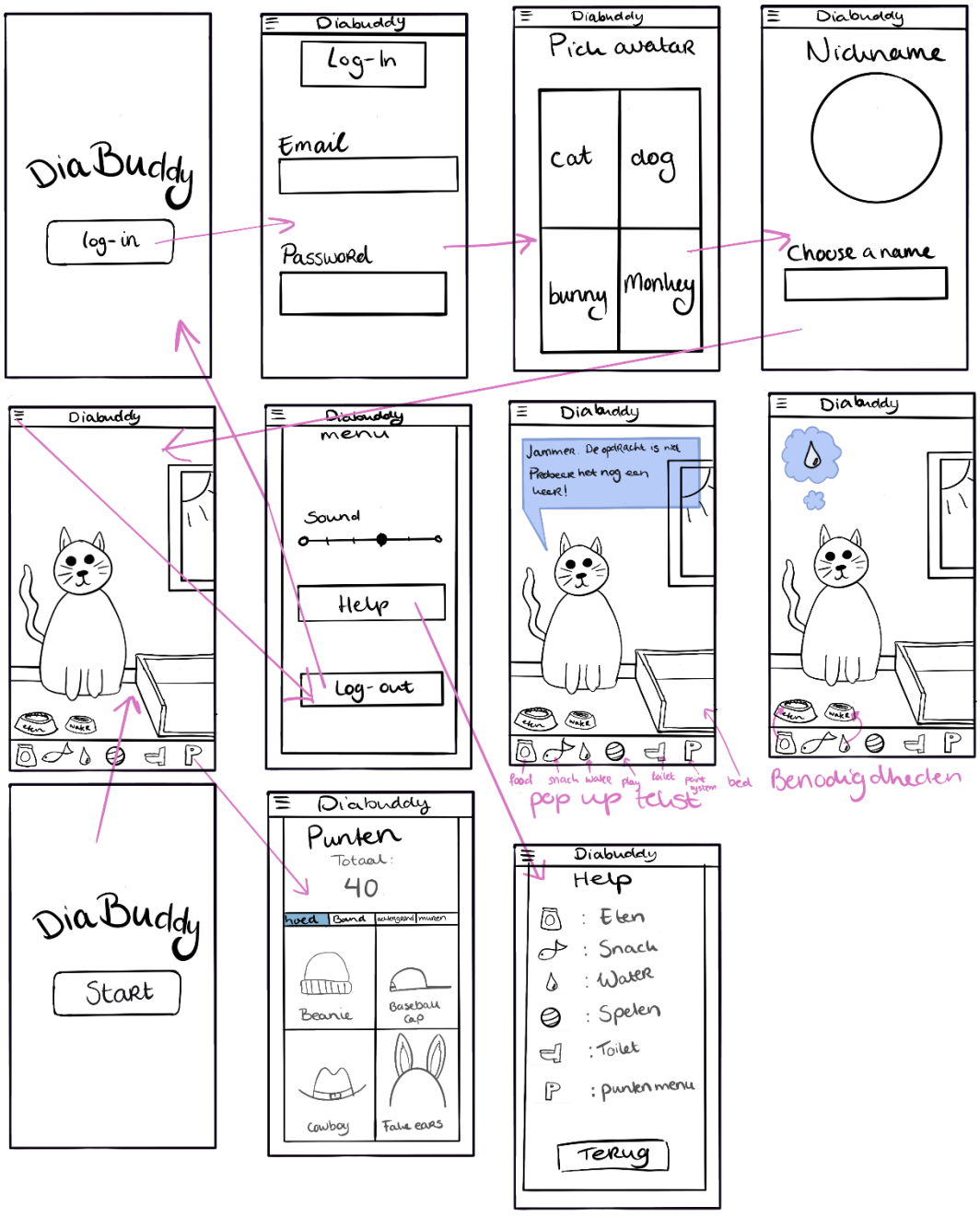
Appendix XI

Evaluation 3, Parent

Performance expectancy	
De app helpt bij een gestructureerde dag creëren voor mij kind.	1. oneens / 5. eens
De app kan helpen bij het inzicht krijgen in het gedrag van mij kind.	1. oneens / 5. eens
Over het algemeen vind ik deze app nuttig.	1. oneens / 5. eens
De beloningen motiveren mijn kind om gestructureerd de app te gebruiken.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het spuiten van insuline.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het meten van zijn/haar bloedsuiker.	1. oneens / 5. eens
De app zal mijn kind helpen (eraan herinneren) bij het tellen van koolhydraten.	1. oneens / 5. eens
Effort expectancy	
Ik vind het gebruik van deze app makkelijk te leren.	1. oneens / 5. eens
Ik vind het gebruik van deze app makkelijk.	1. oneens / 5. eens
Ik vind de indeling en gebruik van deze app logisch.	1. oneens / 5. eens
Social influence	
Ik zou deze app aanbevelen.	1. oneens / 5. eens
Ik denk dat mijn gezin het gebruik van deze app een goed idee vindt.	1. oneens / 5. eens
Ik denk dat mijn kind zijn versie van de app zal gebruiken.	1. oneens / 5. eens
Behavioral intention	
Ik vind het doel en gebruiken van deze app een goed idee.	1. oneens / 5. eens
Ik vind het interessant om deze app te gebruiken.	1. oneens / 5. eens
Use behavior	

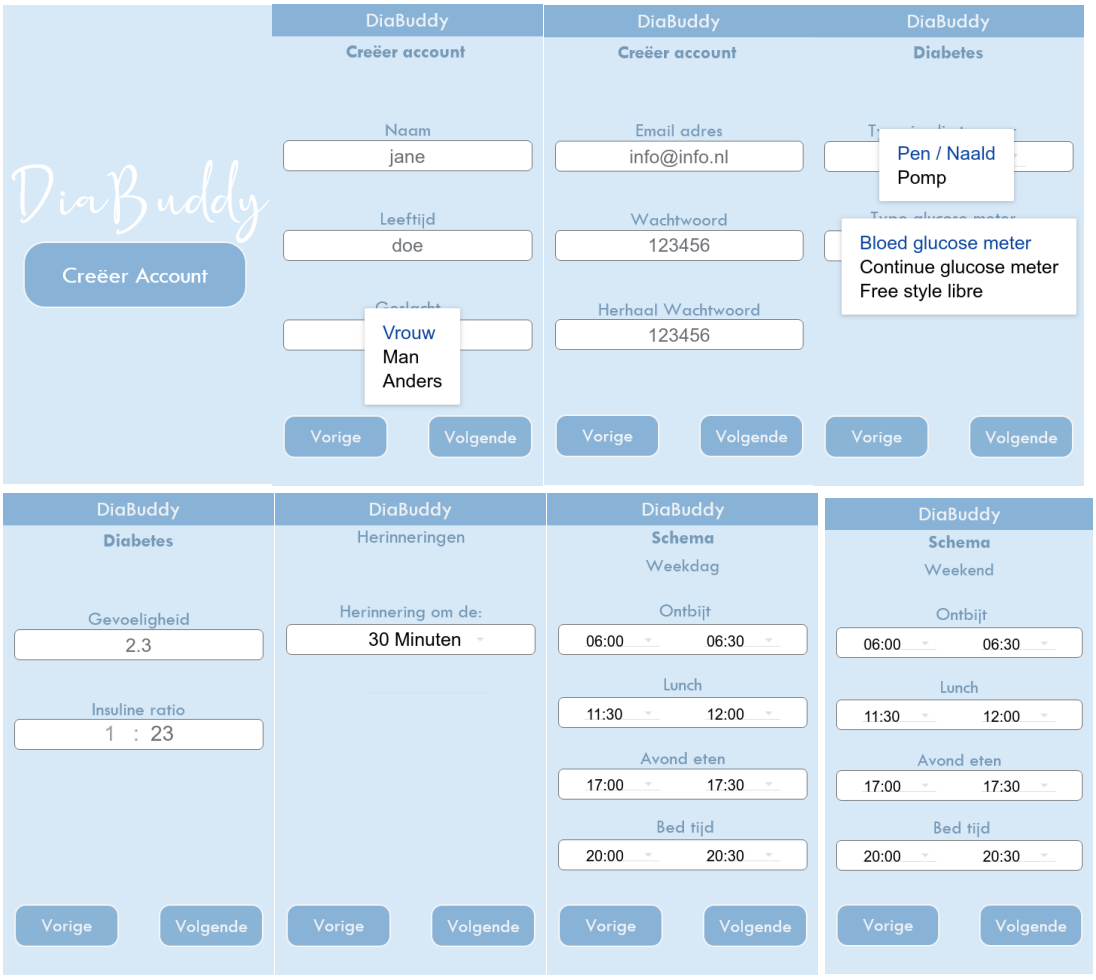
Hoe vaak zou u deze app gebruiken?	1. 1 keer per week / 5. Meerdere keren per week
Ik zou het beloningsysteem gebruiken.	1. oneens / 5. eens
Design	
Ik vind het algemene ontwerp mooi.	1. oneens / 5. eens
Ik vind het algemene ontwerp rustgevend.	1. oneens / 5. eens
Ik vind het algemene ontwerp duidelijk.	1. oneens / 5. eens
Ik vind de grafieken duidelijk.	1. oneens / 5. eens
Questions	
Wat voor een soort functies zouden voor u nuttig zijn? (Die nog niet in het prototype zitten)	Open
Wat vindt u ervan dat u persoonlijke informatie invult?	Open
Wat vindt u ervan dat de app persoonlijk is voor uw kind?	Open
Heeft u nog vragen of opmerkingen?	Open

Appendix XII



Appendix XIII

Appendix XIV



Appendix XV

Android Mobile – 1

Android Mobile – 2

Android Mobile – 3

Android Mobile – 4

Android Mobile – 5

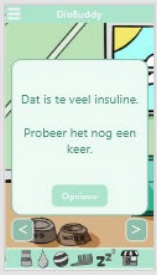
Android Mobile – 6

Android Mobile – ...

Android Mobile – 7

Android Mobile – 8

Android Mobile – 9



Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

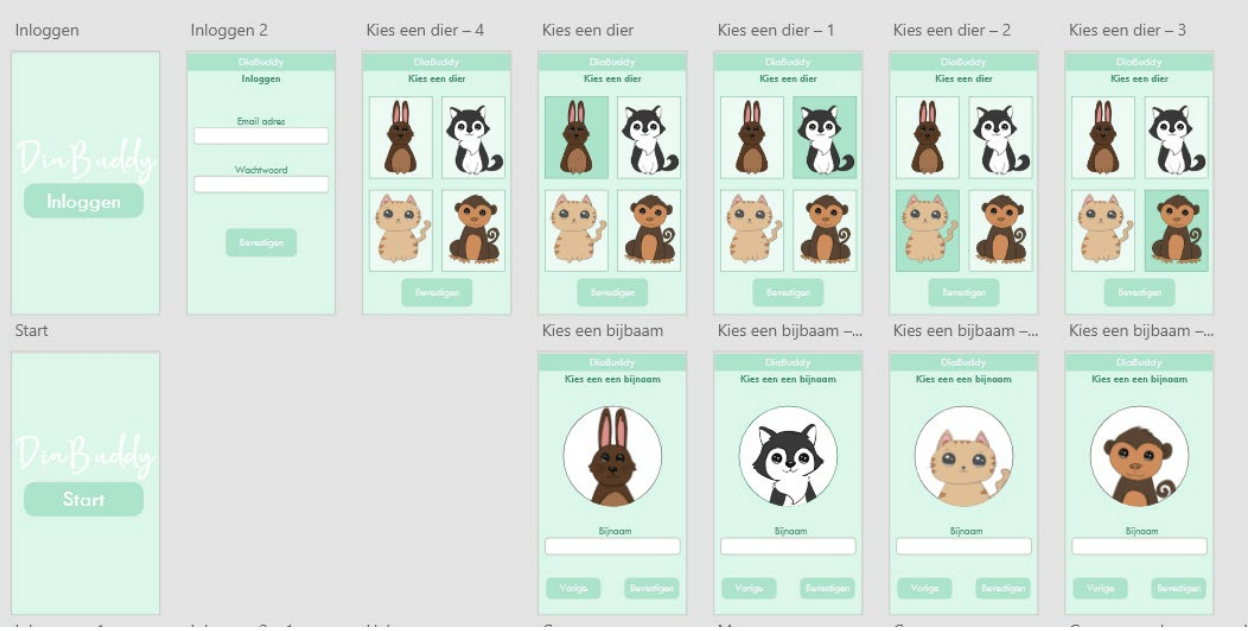
Android Mobile – ...

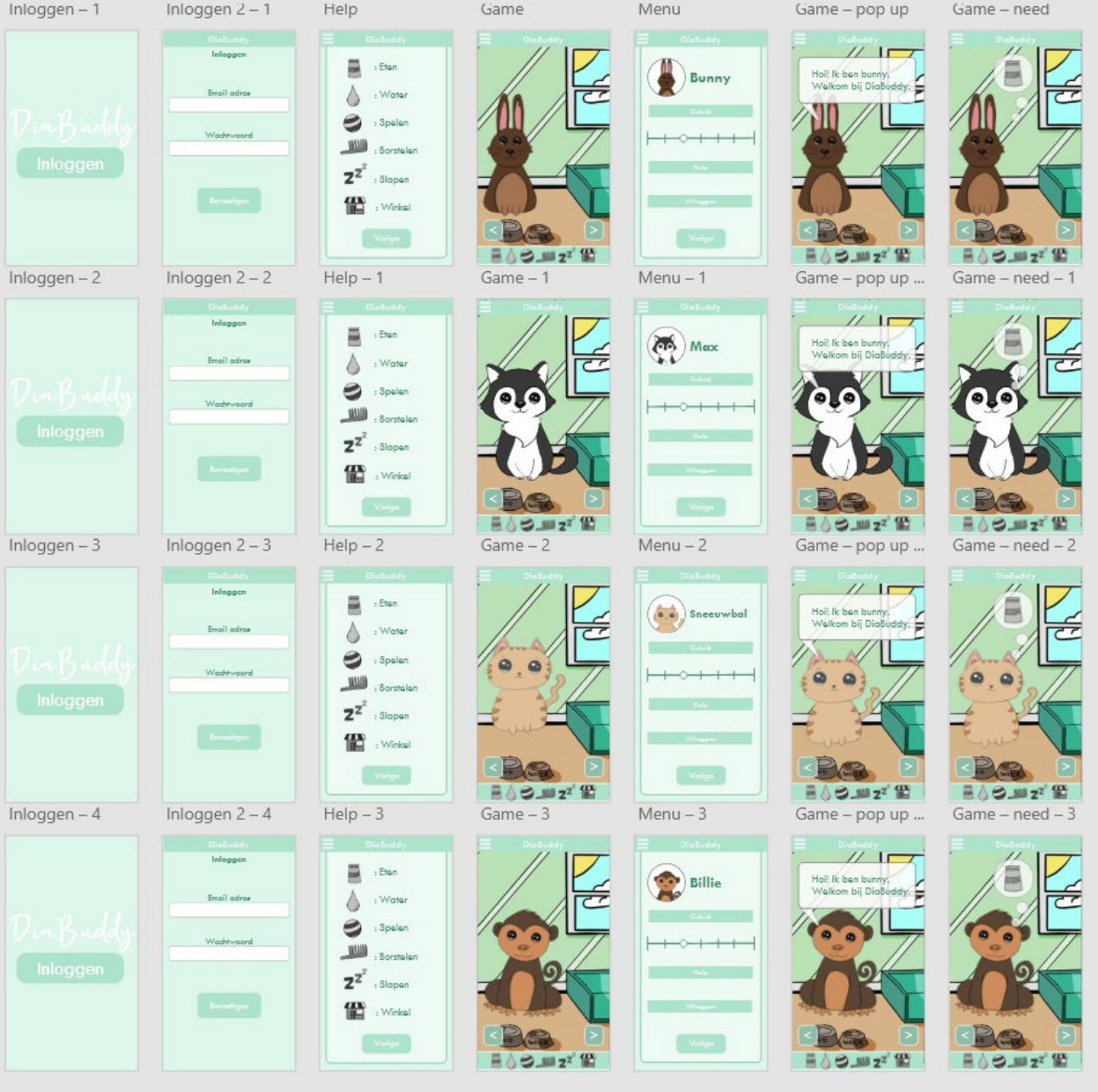
Android Mobile – ...

Android Mobile – ...

Android Mobile – ...

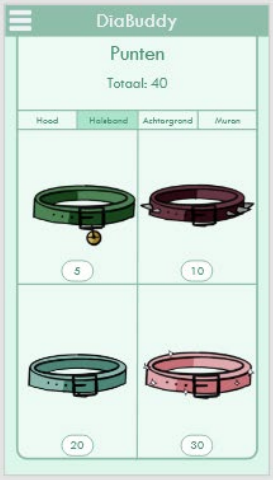
Appendix XVI




Inloggen – 1
Inloggen 2 – 1
Help
Game
Menu
Game – pop up
Game – need
Inloggen – 2
Inloggen 2 – 2
Help – 1
Game – 1
Menu – 1
Game – pop up ...
Game – need – 1
Inloggen – 3
Inloggen 2 – 3
Help – 2
Game – 2
Menu – 2
Game – pop up ...
Game – need – 2
Inloggen – 4
Inloggen 2 – 4
Help – 3
Game – 3
Menu – 3
Game – pop up ...
Game – need – 3
DiaBuddy
Inloggen
Email adres
Wachtwoord
Bevestigen
: Eten
: Water
: Spelen
: Borstelen
: Slapen
: Winkel
Vorige
Bunny
Mexx
Sneeuwbal
Billie
Hoi! Ik ben bunny.
Welkom bij DiaBuddy.

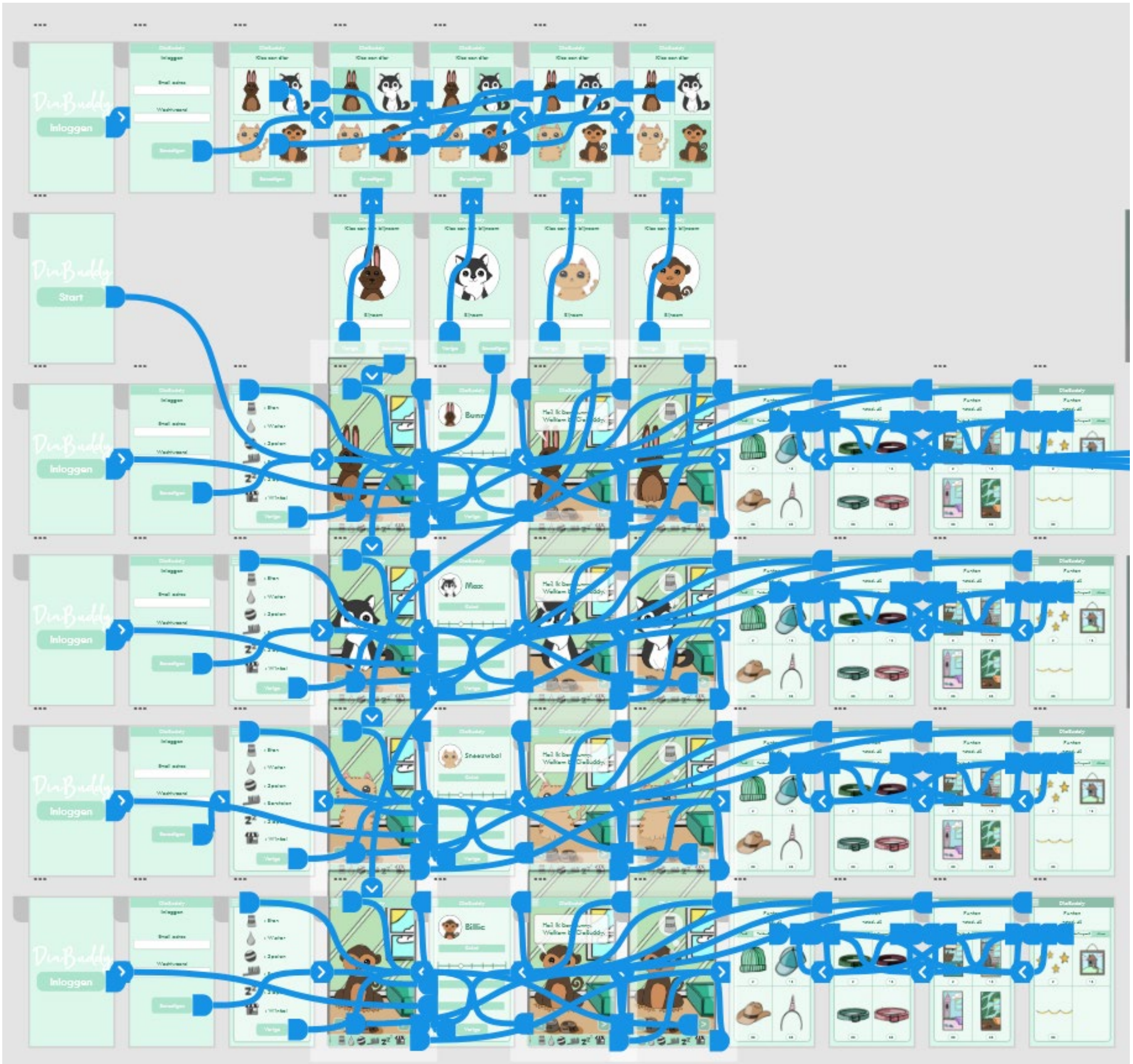
Winkel

Winkel – 1



Winkel – 2

Winkel – 3


Inloggen
Start
Inloggen
Inloggen
Inloggen
Inloggen